Qantex

CARTRIDGE TAPE DRIVE MODEL 650

QNTX TM 1001

Reference Manual

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MODEL 650

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Reference Manual

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STATUS OF CHANGE PAGES

Following is a list of all pages in this manual, their change status and the date of change. A zero (0) in the Change Status column indicates an original issue. Changed text is indicated by a vertical bar in the margin. Changed illustrations are indicated by a vertical bar next to the title.

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SECTION 1

GENERAL DESCRIPTION

1.1 GENERAL

This manual contains a general description, installation and operating instructions, theory of operation, maintenance and troubleshooting procedures, parts lists and schematics for Cartridge Tape Drive, Model 650 (herein after referred as the tape drive).

1.2 PHYSICAL DESCRIPTION

The tape drive (fig. 1-1) is a rugged machine designed to operate continuously and reliable in an EDP environment. When effectively installed and maintained, the tape drive will have an operational life of many years. This life results from the use of stainless steel mechanisms and conservative design practices.

The tape drive uses a three-point suspension system for aligning the data cartridge with the magnetic head assembly. The cartridge is held firmly by two latch arms. Each point has a small roller which minimizes wear of both the point and the data cartridge.

When a data cartridge is loaded, it is locked in place by two latches. They provide stops against which the data cartridge is pushed by the ejection spring. The stops govern the depth to which the magnetic head assembly enters the data cartridge, assuring contact of the magnetic head assembly with the magnetic tape as required to read, write, and erase data.

The tape drive can be mounted to a front panel or to side panels. It can be mounted in any attitude, vertical or horizontal. Tapped holes on its front mounting surface provide for mounting to the back of a front panel. Alternatively, mounting tabs can be fastened to these holes for sliding the tape drive through a cutout in a front panel and securing from the front. Tapped mounting holes are furnished on the sides of the tape drive, which permit it to be mounted to overhead, side, or bottom panels. A selection of bezels is available for nomenclature and styling. The nomenclature can be lettered either horizontally or vertically, either Qantex standard or specially designed to meet customer specifications.

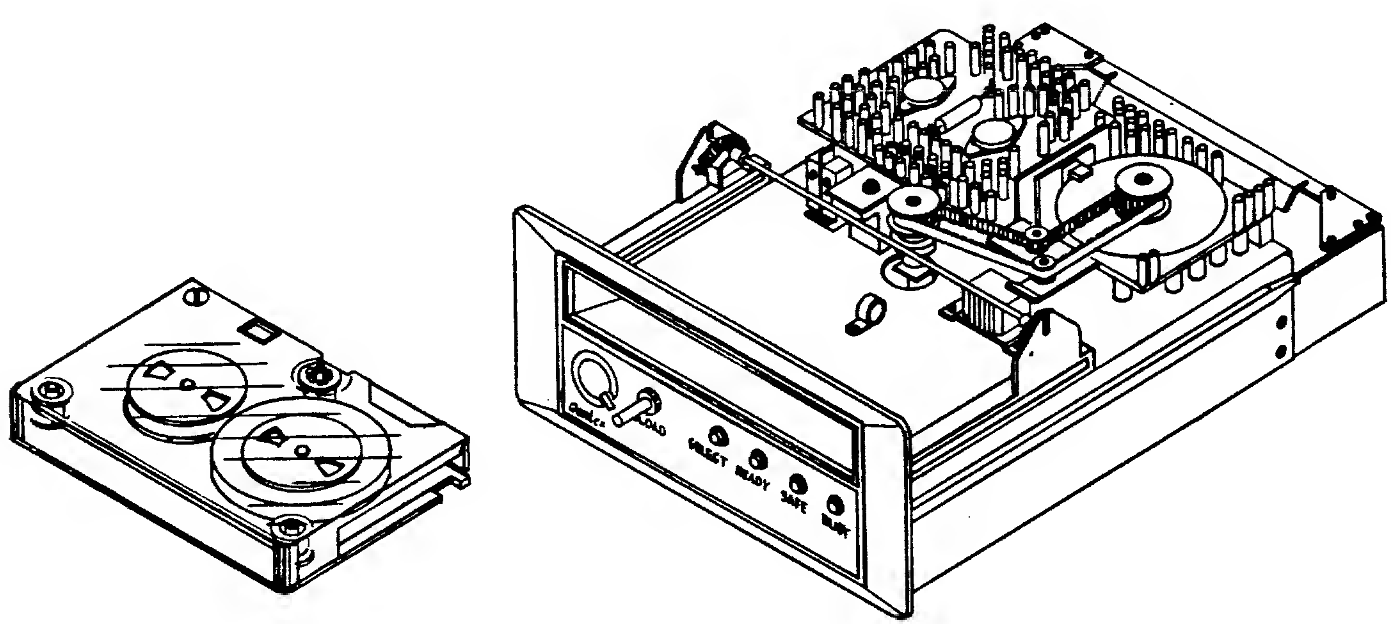


Figure 1-1. Cartridge Tape Drive, Model 650

Figure 1-2 is a diagram of the data cartridge, and shows the relative positions of the magnetic head, the drive roller and the tape mark sensor. Figure 1-3 illustrates the physical points of the tape, including BOT, LP, Early Warning, and EOT holes. It also shows the locations of the tracks.

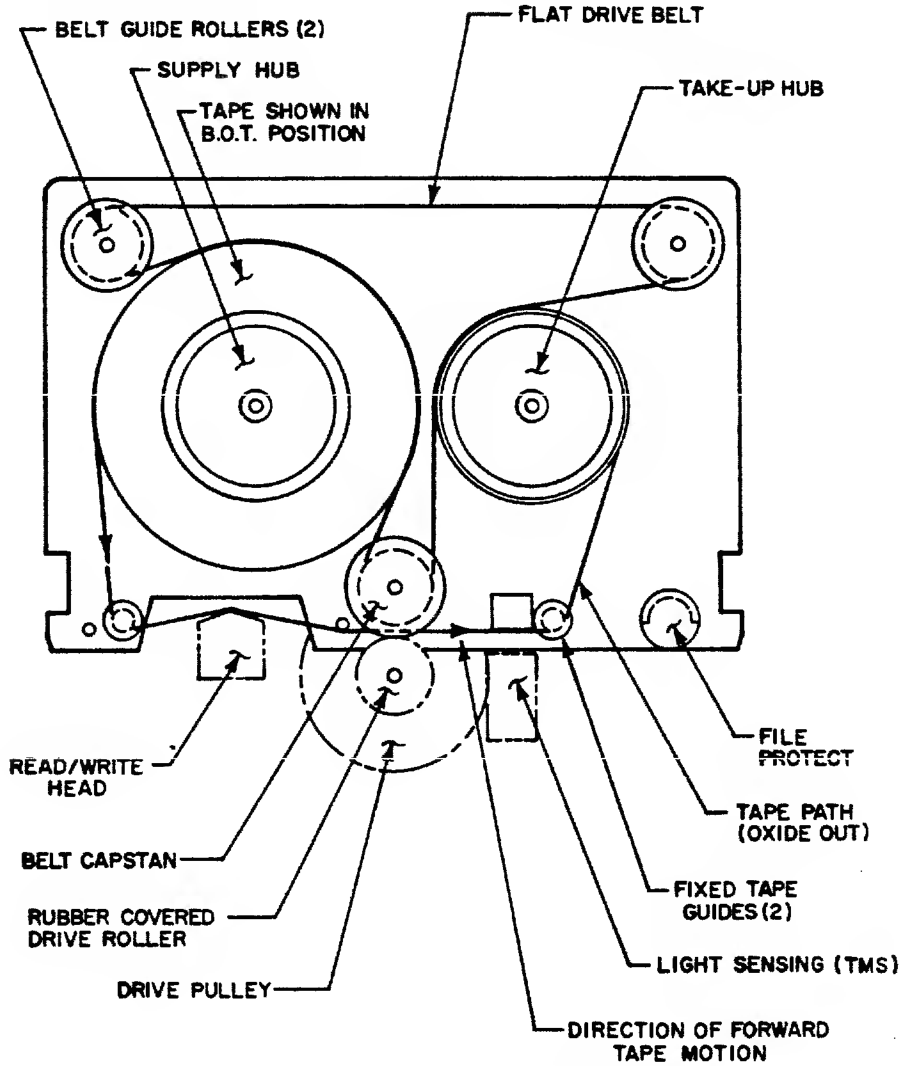


Figure 1-2. Data Cartridge

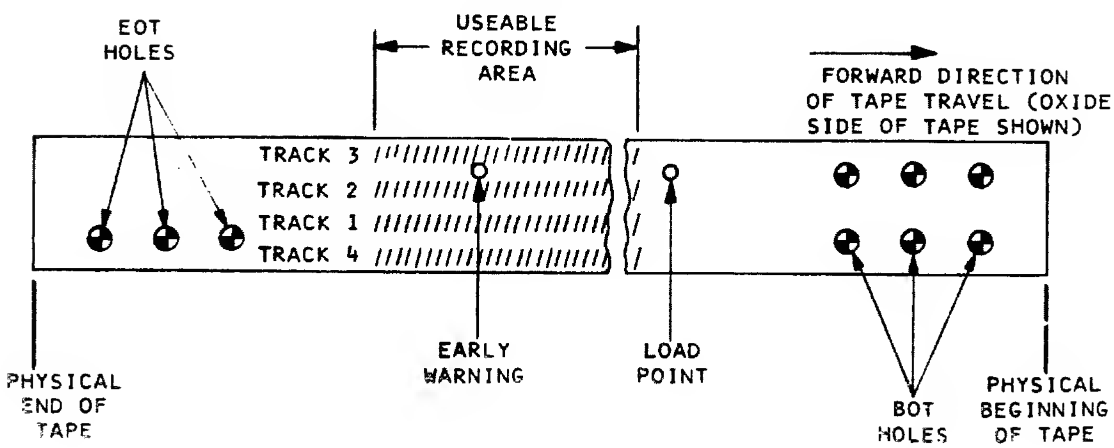


Figure 1-3. Tape Position Holes and Recording Format

1.3 FUNCTIONAL DESCRIPTION

The tape drive is a magnetic tape transport. It is used as a computer input/output device for retrieving and storing data using "Scotch" Brand DC300A data cartridges for the recording medium described in ANSI specification X3/B5/15. The tape drive can be used in computer systems, data terminals and associated EDP machines.

In the standard model, the data cartridge can be ejected either mechanically or electrically. Electrical ejection allows the data cartridge to be expelled by a remote command and permits features such as automatic rewind and eject (Unload). When a cartridge is loaded, it actuates a status switch (cartridge in place). A second status switch detects the position of the File Protect mechanism on the data cartridge.

The electrical circuits of the tape drive are organized into three basic assemblies; control board, servo/data board, and drive mechanism with its associated electronics. These circuit groupings and their fundamental functions are shown in figure 1-4. (Optional variations of the tape drive are supplied without the control board or both the control board and servo/data board.

1.3.1 Control Board

The control board accepts command signals and data from the system, and status information from the tape drive. It interprets these signals and generates motion control signals for the servo/data board. The motion control signals cause the tape to move as required to read or write data, search, rewind or position tape. Based on the state of the tape, the cartridge, and the drive, the control board generates status output signals.

1.3.2 Servo/Data Board

The servo/data board operates the electrical assemblies mounted on the drive mechanism according to the control signals received from the control board. It contains servo amplifiers, read/write amplifiers, and status logic. The servo amplifier compares the feedback signal from the optical tach with the command signals for 30 ips, 90 ips, or stop. If there is a difference between the two signals, it is amplified

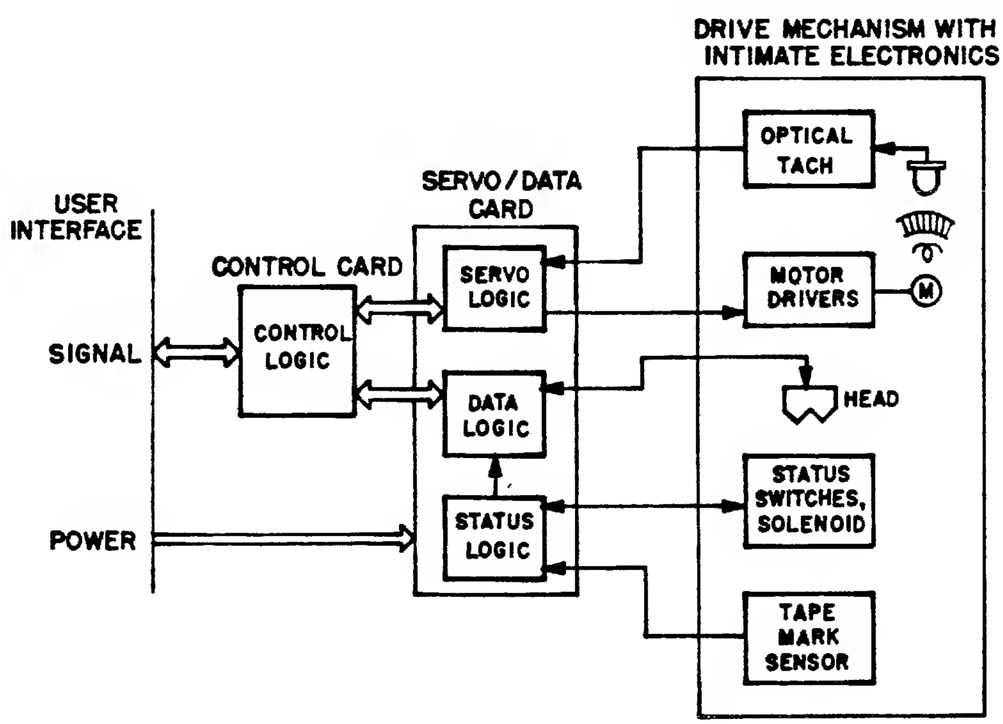


Figure 1-4. Tape Drive, Block Diagram

and used to speed up or slow down the servo motor as required to maintain tape speed at precisely 30 or 90 ips.

When the servo/data board receives a stop motion command, it decelerates the tape smoothly to 0 ips. The deceleration function approximates a ramp. Conversely, tape is accelerated to speed in response to a tape run command. The overall waveform approximates a trapezoid.

The read/write circuits on the servo/data board implement a number of data handling functions. Depending on the configuration of tape drive, it will be supplied with a single or dual gap head. The single gap head is used for the read and write function; the dual gap head for the read-after-write function. The addition of an optional erase head provides an erase-before-write function. Data is read or written serially on one track at a time, and must be phase-encoded. The standard tape drive has a four track head, but decode circuits allow only one of these tracks to be used at a time. Read amplifiers decode the electrical output of the magnetic heads. They apply noise margins to the read data of either 5% or 10%; 5% during a normal read operation, 10% during a read-after-write operation. The output data consists of a phase-encoded (PE) pulse train.

1.3.3 Drive Mechanism

The drive mechanism (fig. 1-4) is a part of the main chassis assembly of the tape drive. It contains servo power and amplifier and drive components, status switches and sensors, and the cartridge loading and eject mechanism. The servo power amplifier consists primarily of two Darlington power transistor arrays which drive the servo motor. The servo motor turns a drive wheel assembly by way of the drive belt. The assembly has a friction drive wheel which contacts the capstan within the cartridge. The servo motor also turns the slotted disc of an optical tachometer. The output of the tachometer is a series of pulses, used by the servo/data board, to provide a constant servo motor speed.

1.3.4 Status Sensing

Several status sensing devices are located on the main assembly. A Cartridge-in-Place switch detects the presence of a tape cartridge. A Safe switch detects the position of the file protect mechanism located on the data cartridge. A photo detector detects BOT, EOT, Load Point, and Early Warning. The output of these sensors is used by the control logic to generate motion control signals for the servo, and status signals for the system.

1.4 SPECIFICATIONS

The specifications of the tape drive are listed in table 1-1.

1.5 OPTIONS

The tape drive is manufactured in a wide variety of configurations, each specified by its order number listed in table 1-2.

Table 1-1. Specifications

Item	Specification
Storage device	Scotch Brand DC300A data cartridge
Storage medium	Magnetic tape (computer grade)
Tape length	300 ft.
Tape width	1/4 inch

Table 1-1. Specifications (Continued)

Item	Specification
Tape speed	
Read/Write	30 ips, bidirectional
Search/Rewind	90 ips, bidirectional
Variation	±3%, long-term
Start/stop time	
at 30 ips	27 ±2 mS
at 90 ips	75 ±5 mS
Start/stop distance	Start / Stop
at 30 ips	0.485 inch ±20% / 0.12 inch ±20%
at 90 ips	3.3 inch ±20% / 1.3 inch ±20%
Recording density	1600 bpi, 3200 flux reversals per inch
Recording mode	Phase encoding
Data transfer method	Serial
Number of tracks	4
Type of heads	
Read-after-Write	Dual gap head (standard)
Read/Write	Single gap head (optional)
Selective erase	Erase head (optional)
Threshold levels	
Read-after Write	10% noise margin
Read	5% noise margin
I/O circuits	DTL/TTL
Interface logic power	Low is true (negative logic)
Power	+5 Vdc ±3%, 1 A max. +18 Vdc ±3%, 250 mA [idle, 1 A (running)] NOTE 4.2 A surge required during start and stop time from either +18 V or -18 V power supply, depending on tape direction.
Dimensions	
with electronics	3-1/8"H x 7"W x 10"D
without electronics	3-1/8"H x 7"W x 8-1/4"D
Weight	4.5 lbs. max. (not including 9 oz. data cartridge)
Ambient temperature	
Operating	+5°C to +45°C
Storage	-30°C to +60°C
Relative humidity	
Operating	20% to 80% (no condensation)
Storage	0% to 95% (no condensation)
Control documents	
Data cartridge	ANSI Specification X3/B5/15
NAI specification	Q-1083/Q1133

Table 1-2. Configuration Options

Order No.	Item	Code	Option
1	Number of tracks	4T	4 tracks
2	Type of head	* DGH DGE	Dual gap head Dual gap and erase head
3	Circuit boards supplied	1PC * 2PC XPC	Servo/data card only Servo/data card and control card No cards supplied
4	Type of ejection	1E * 2E 3E	Manual ejection of cartridge Manual or electrical ejection of cartridge Electrical ejection of cartridge
5	Type of bezel	* 1B 2B 3B 4B 5B XB	Standard bezel with horizontal lettering (Qantex logo) Standard bezel with vertical lettering (Qantex logo) Standard bezel with horizontal lettering (no logo) Standard bezel with vertical lettering (no logo) Standard bezel with custom label No bezel supplied
6	Status display indicators	* 1D 2D XD	4 indicators: SELECT, READY, SAFE, BUSY 3 indicators: READY, SAFE, BUSY No indicator
7	Auto load	1L XL	Tape automatically advances to Load Point (LP) N/A
8	Unit select coding	1S * 2S XS	Factory wired address Coding switch mounted on control card. User can select or change address code. No Coding (customer must jumper program)
9	Terminator network	* 1T 2T 3T	Terminator socket with network Terminator socket without network Factory-wired terminator network
10	Data tracker control card	1P	A phase decoder circuit is provided on the control card. Read data is decoded data.
11	No auto load on power-up	* RS1	Factory wired jumpers resets auto load circuits on power-up. If cartridge is left in the tape drive, it will not go into Auto Load cycle on power-up.

*Standard units.

SECTION 2

INSTALLATION

2.1 GENERAL

This section contains information and procedures to aid in installing the tape drive.

2.2 UNPACKING

The tape drive is shipped in a cardboard carton (fig. 2-1). The unit is held firmly in place by styrofoam pads at either end. Unpack unit as follows:

a. Place carton in upright position.

b. Check carton for damage. Note any damage in receiving records.

c. Slit tape carefully and open carton.

d. Remove unit.

e. Discard end pads.

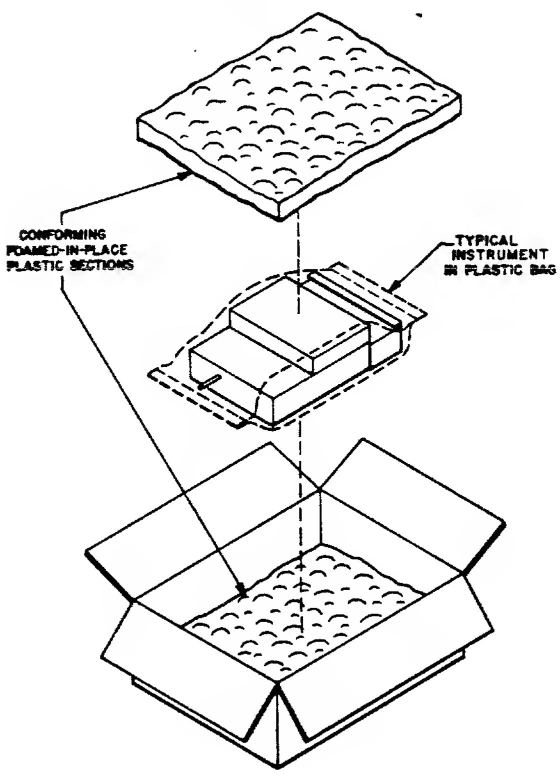


Figure 2-1. Packing Tape Drive

2.3 INSPECTION

Inspection consists of carefully checking the unit to assure that it was not damaged in transit. Inspect as follows:

a. Carefully examine for physical damage. If damage is found, notify carrier.

b. Check that all components and circuit boards are in place.

2.4 INSTALLATION

Installation consists of physically mounting the tape drive into desired enclosure.

The tape drive has been designed for installation in user equipment in a variety of ways. They include mounting to the back of a front panel, from the front of a front panel and to a side panel or brackets. The tape drive will operate in any position. Caution must be exercised, however, when installing it overhead. During operation the data cartridge is locked in place, but once the UNLOAD button is pressed, it is free to slide out. If unrestrained, both operator and data cartridge could be impaired. The overall dimensions of the tape drive are shown in figure 2-2. Detail installation procedures are given in the following paragraphs.

2.4.1 Back of Front Panel Mounting

The tape drive can be attached to the back of a front panel (fig. 2-3). The panel cutout for this arrangement is shown in figure 2-3B. Install the tape drive to the front panel (fig. 2-3A) as follows:

a. Remove bezel from tape drive by unscrewing UNLOAD bushing and carefully pulling bezel free.

b. If supplied, remove and discard mounting brackets. Save screws.

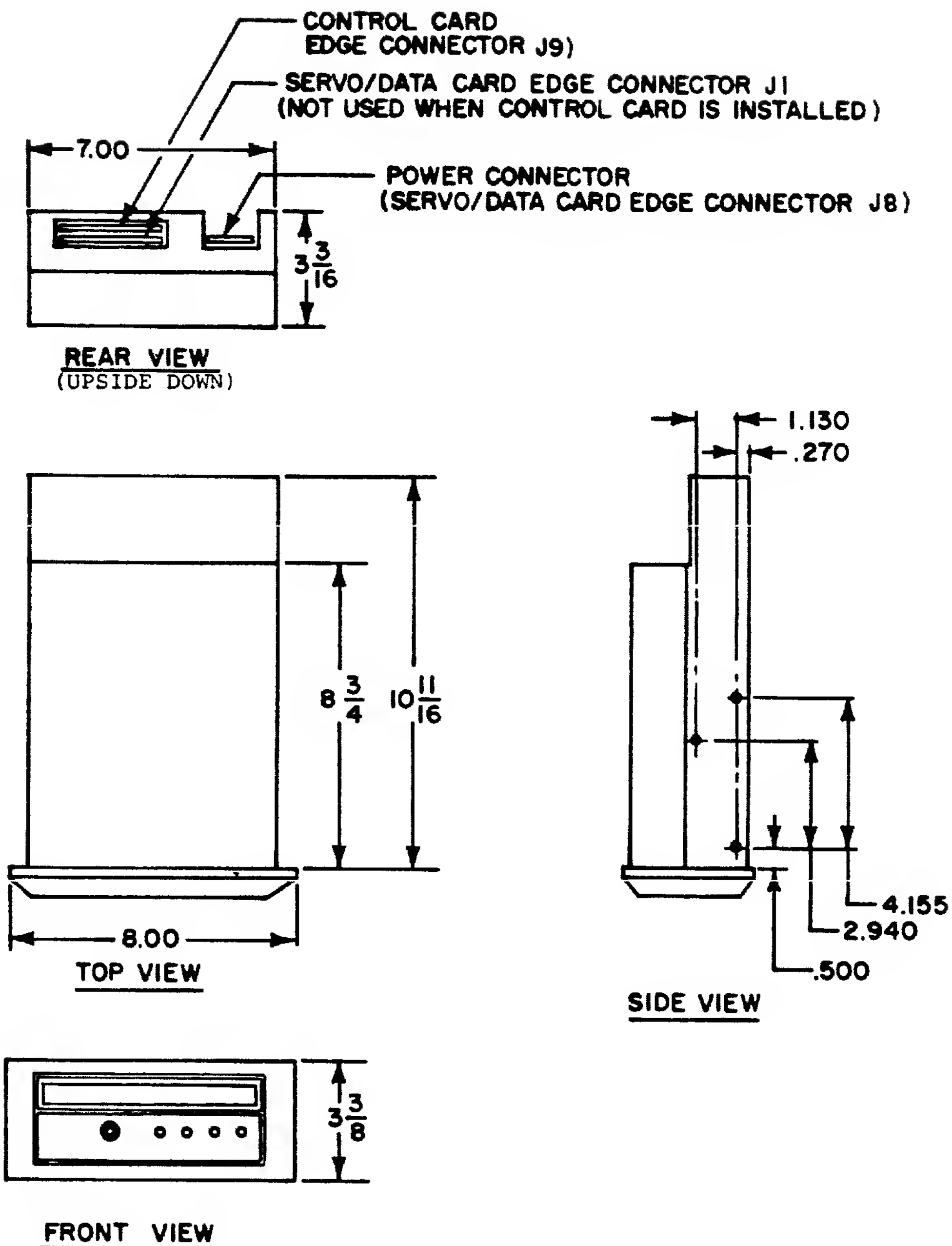


Figure 2-2. Outline Drawing

c. Fasten tape drive to the front panel with the four screws removed in step b.

d. Replace bezel. Screw UNLOAD bushing into place until tight.

2.4.2 Front Panel Mounting

The tape drive can be attached to the front of a front panel as shown in figure 2-4A. Proceed as follows:

a. Remove bezel from the tape drive by unscrewing UNLOAD busing (fig. 2-3A) and carefully pulling bezel free.

b. Connect I/O and power connectors (fig. 2-2).

c. Slide the tape drive through cutout in panel.

d. Use four #6 screws to fasten in place (fig. 2-4A)

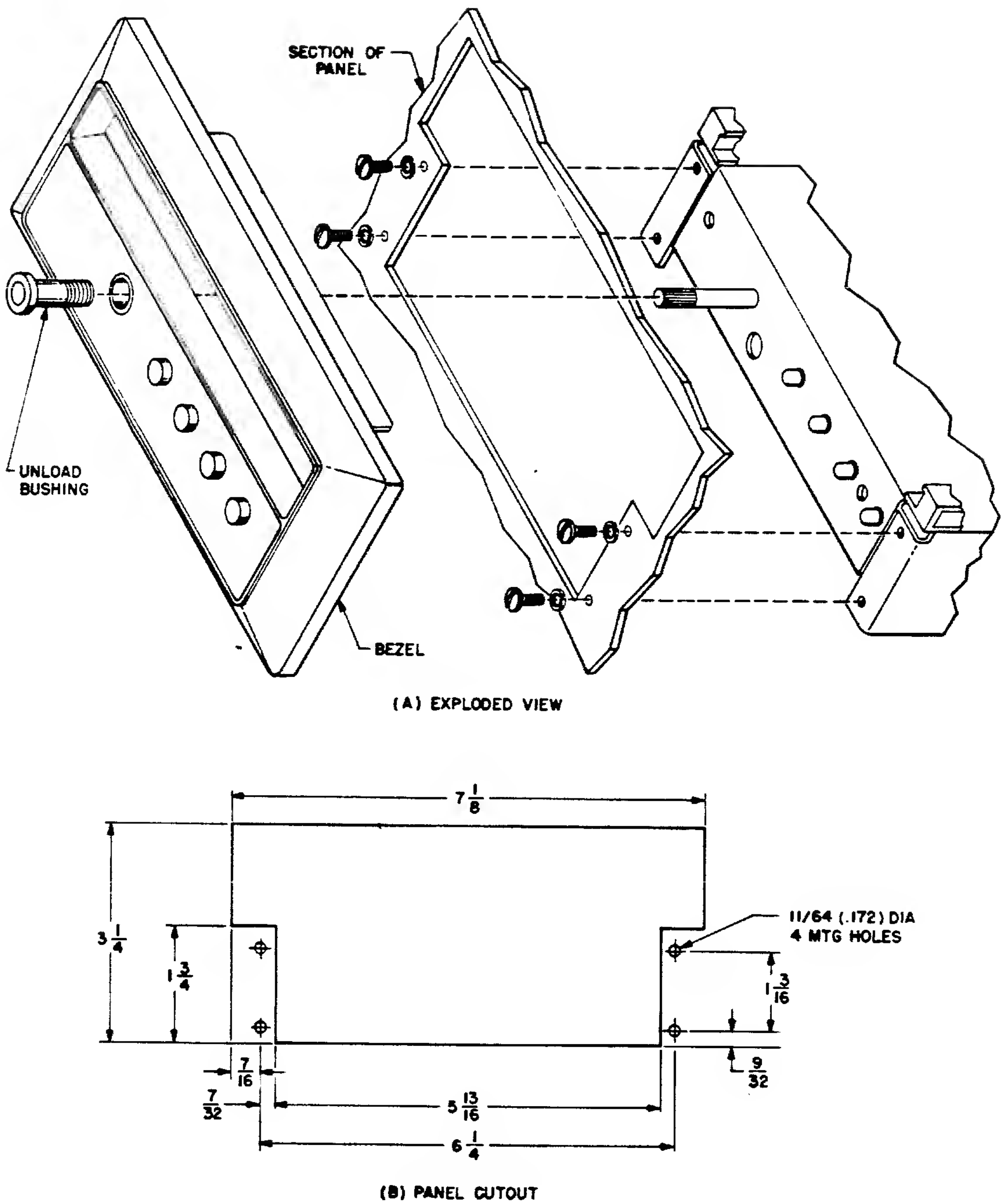


Figure 2-3. Mounting to the Rear of a Front Panel

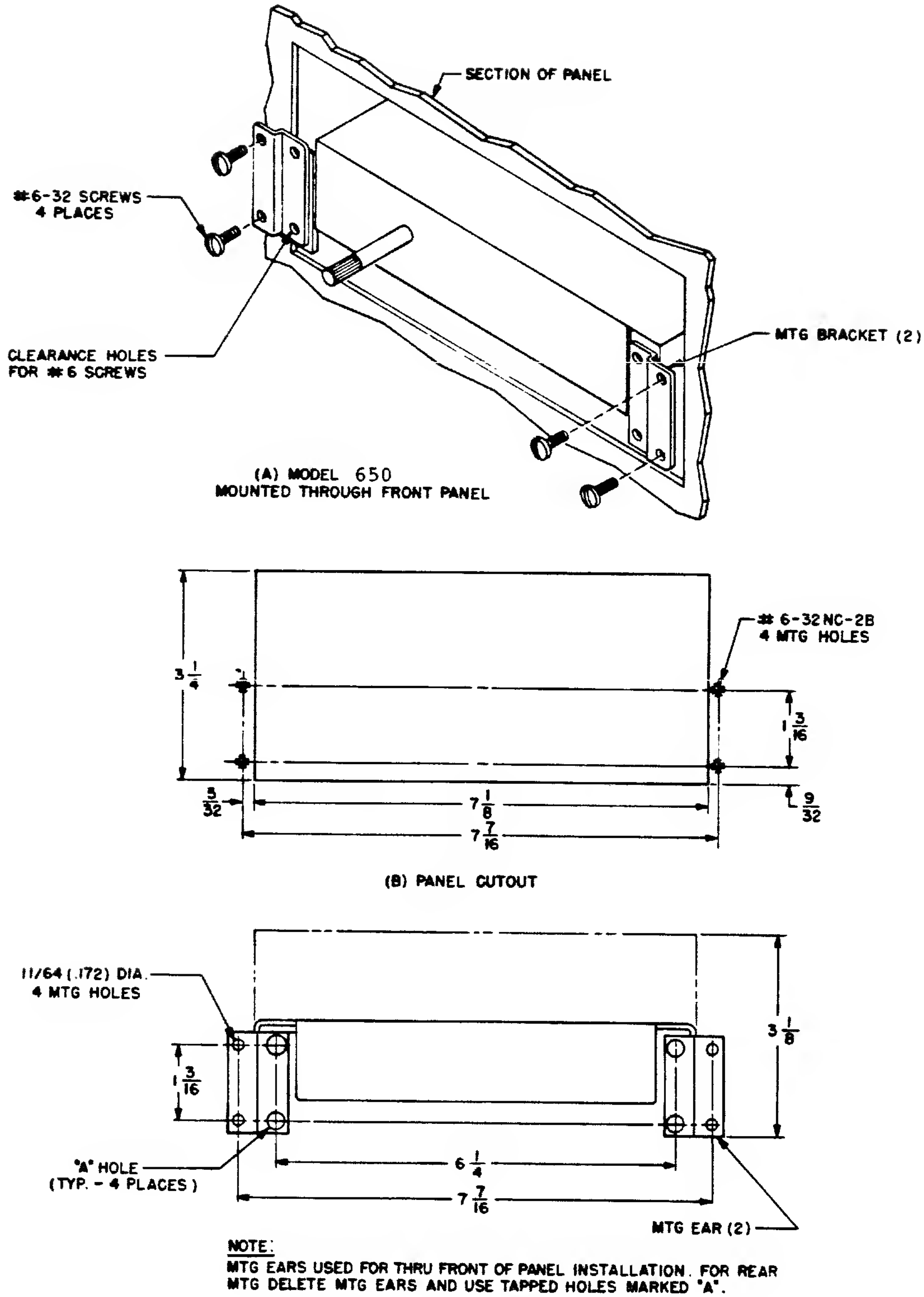


Figure 2-4. Mounting to Front of a Front Panel

e. Replace bezel. Screw UNLOAD bushing into place until tight (fig. 2-3A).

2.4.3 Side Mounting

The tape drive can be mounted by its sides as illustrated in figure 2-5. Four tapped holes in either side accept four 6-32 mounting screws. The panel cutout in figure 2-4B can be used with this application. A typical installation procedure follows:

a. Remove bezel from the tape drive by unscrewing UNLOAD bushing (fig. 2-3A) and carefully pulling bezel free.

b. If supplied, remove and discard mounting brackets (fig. 2-4A) and screws.

c. Use four 6-32 screws to fasten the tape drive to a side panel or bracket (fig. 2-5).

d. Connect I/O and power connectors.

e. Install front panel of user's equipment.

f. Replace bezel. Screw UNLOAD bushing into place until tight (fig. 2-3A).

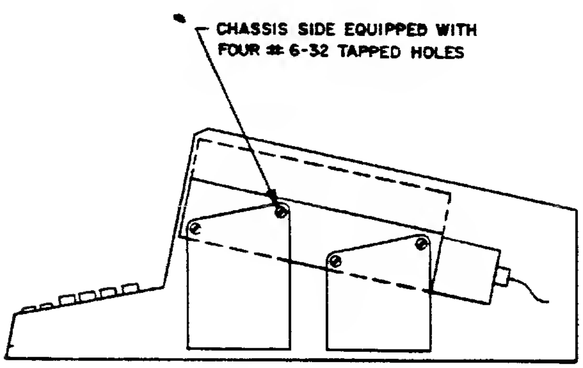


Figure 2-5. Side Mounting

2.5 COOLING

The power dissipated by the tape drive, when tape is moving, is 30 watts. The forced air cooling is dependent upon the ambient air temperature and the duty cycle of the drive. Heat is removed by cooling air passing over the heat sink assembly. The maximum temperature of the cooling air adjacent to the tape drive should not exceed 45°C. A lower ambient temperature and higher airflow rate will lengthen the life of the equipment.

NOTE

The data cartridge is specified for operation over the temperature range of +5°C to +45°C.

2.6 POWER REQUIREMENTS

The power requirements for the tape drive depend upon which of the three circuit board options has been specified. These options are described in table 1-2 and specified as 1PC, 2PC, or XPC.

2.6.1 Power for Options 1PC and 2PC

If options 1PC and 2PC are supplied, the tape drive will require power as follows:

- +5Vdc ±3% at 1 ampere maximum
- +18Vdc ±3% at 250mA when idle, 1 ampere while running at 30 ips, (1.5 amperes at 90 ips), 4.2 amperes during stops and starts. (+18V is used only for reverse motion.)
- -18Vdc (same as +18Vdc except used only for forward motion).

Power is connected to the printed circuit edge connector on the servo/data board. The power connector uses an AMP #582140-2 housing and 42717-3LP crimp contacts. The connector pins are wired as follows:

Pin	Signal
J8-1	-18 Vdc
J8-2	+18 Vdc
J8-3	Motor ground
J8-4	Not used
J8-5	+5 Vdc
J8-6	Logic ground
J8-7	+12 Vdc (Optional)
J8-8	-12 Vdc (Optional)

NOTE 1

Motor and logic grounds should be connected at the power supply.

NOTE 2

Improper orientation of connector will not cause damage unless tape drive is equipped with the optional 12 V on pins 7 and 8.

NOTE 3

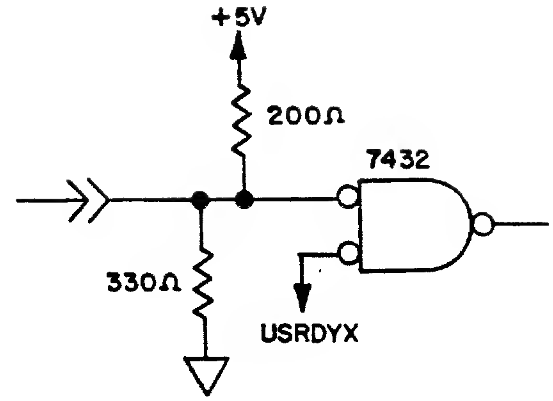
Number 18 AWG wires are recommended for power supply connections. Recommended length of power cable from power supply to tape drive is 5 feet.

2.6.2 Connections for Option XPC

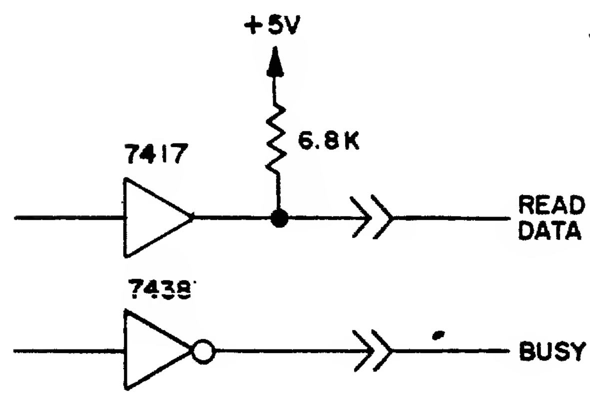
If option XPC has been specified, the user must interface directly to the components mounted on the main assembly. These components can be accessed by way of the four connectors on the wiring harness. These are Berg Electronics, Type 65039-031 connectors with Type 47714 contacts and are wired according to table 2-4.

2.7 INPUT/OUTPUT CONNECTOR

The input/output signal requirements of the tape drive depend upon which of the three circuit board options has been specified (table 1-2, item 3). The I/O signal requirements are described in the following paragraphs. All logic lines are compatible with TTL or DTL. Typical drivers and receivers are shown in figure 2-6.



A. TYPICAL LINE RECEIVER/TRANSMITTER CONTROL (2PC) INTERFACE



B. TYPICAL LINE TRANSMITTERS CONTROL (2 PC) INTERFACE

Figure 2-6. Typical Line Reciever and Transmitter

2.7.1 I/O Signals for Option 2PC

Option 2PC is standard. It includes both the control board and the servo/data board The control, status, and data lines are connected to the control board edge connector (fig. 2-2, rear view) using a 3M #3415 connector and a #3365/50 flat cable. The length of the cable should not exceed 15 feet. As far as possible, ribbon cable should be used for signal I/O connectors. Odd numbered pins should be signal ground on both sides of the signal cable. If single wires are used, for I/O connectors, they should be twisted pairs with signal ground on both ends of the I/O connection. The connector is wired according to table 2-1. Table 2-2 provides the alternate I/O signals (pins 2, 16, 46, 50) for the optional control board with data tracker circuit (Option 1P).

2.7.2 I/O Signals for Option 1PC

Option 1PC includes a servo/data board only. The control, status, and data lines are connected to the servo/data board edge connector (fig. 2-2, rear view) using the 3M #3415 connector and a #3365/50 flat cable.

Table 2-1. Standard Control Card Pin Assignment (J9)

Pin	Signal Name	Input/Output	Level/Pulse	Active State
2*	Eject	Input	Pulse	Low
4	Select CX	Input	Level	High
6	Select C	Input	Level	Low
8	Select BX	Input	Level	High
10	Select B	Input	Level	Low
12	Select AX	Input	Level	High
14	Select A	Input	Level	Low
16*	BOT/TACHO	Output	Pulse	Low
18	End of Tape (EOT)	Output	Level	Low
20	Busy	Output	Either	Low
22	File Protect (FP)	Output	Level	High[2]
24	Tape Run	Input	Level	Low
26	Rewind	Input	Either	Low
28	Unload A	Input	Either	Low
30	FWD/REV	Input	Level	Low[3]
32	Ready	Output	Level	Low
34	Load Point	Output	Level	Low
36	Early Warning (EW)	Output	Pulse	Low
38	Hi/Lo	Input	Level	Low[4]
40	Write Data	Input	Level	Low
42	Track Select A	Input	Level	Low
44	Track Select B	Input	Level	Low
46*	Read Data	Output	Level	Low
48	Read/Write	Input	Level	Low[5]
50*	Unload B	Input	Level	Low[1]

[1]Used in optional configuration

[2]File Protected

[3]FWD

[4]High-Speed

[5]Write

NOTES: 1. All odd-numbered pins are signal ground.
2. All outputs and command inputs are controlled by Select (pins 4 to 14).
3. All outputs and inputs are bussable.

*See table 2-2 for optional signals on these pins when tape drive is specified with optional VCO control board assy. 786604.

Table 2-2. Alternate Control Board Pin Assignments (Option 1P)

Pin	Signal Name	Input/Output	Level/Pulse	Active State
2	Data Present	Output	Level	Low
16	Data Valid	Output	Level	Low
46	Decoded Data	Output	Level	Low
50	Data Strobe	Output	Pulse	Low

The length of the cable should not exceed 12 inches. The connector is wired according to table 2-3.

2.7.3 I/O Signals for Option XPC

No circuit cards are provided with option XPC. Components on the tape drive assembly are driven directly by user designed circuits. The components are accessed by way of the four connectors on the assembly wiring harness. They are Berg Electronics, Type 65039-031 connectors with 47714 contacts and are intended to mate with pins mounted on the circuit cards. The connectors are wired according to table 2-4.

2.8 LINE DRIVERS AND RECEIVERS

Typical line drivers and a line receiver are illustrated in figure 2-6. These are TTL devices and are compatible with both TTL and DTL. A low on an input/output line should be between 2.8 and 5 volts. For the 2PC option, all interface signals are via the control board.

A signal on an interface line is true when the voltage level is low, and false when it is high. All outputs, except Read Data are from open collector IC's (type 7438). Read Data uses an open collector IC (type 7417). Outputs and inputs are enabled only when

Table 2-3. Servo/Data Board Pin Assignments (J1)

Pin	Signal Name	Input/ Output	Level/ Pulse	Active State	Notes
2	USRDYX	Input	Level	Low	One TTL input
4	FPX	Output	Level	High	Output from 7404
6	FASTAX	Input	Level	Low	1 kΩ to +5 and 2 TTL inputs
8	FWDAX	Input	L/P	Low	1 kΩ to +5 and 3 TTL inputs
10	Busy	Output	Level	High	Output from 7404
12	RDYIX	Output	Pulse	Low	Output from 7476
14	CLKENX	Output	Level	Low	Outupt from 74123
16	Unload SW (J6-5)	Output	Pulse	Low	
18	USEJECTX	Input	Level	High	1 TTL input
20	REWUN	Input	Pulse	High	2 TTL inputs
22	LDX	Output	Pulse	Low	Differentiated pulse output
24	TMSB	Output	L/P	High	Output from 74123
26	FE	Input	Level	High	If not used, must be tied low
28	USIX/Unload SW (J2-1)	Input	Pulse	Low	1 kΩ to +5 and switch
30	STSP	Output	Level	High	Output from 7404
32	Read/Write	Input	Level	Low	One TTL input
34	Ready	Output	Pulse	High	Output from 7427
36	SEOTX	Output	Pulse	Low	Output from 74132
38	SEWX	Input	Level	Low	Output from 74132
40	Write Data	Input	Level	Low	One TTL input
42	Track Select A	Input	Level	Low	One TTL input
44	Track Select B	Input	Level	Low	One TTL input
46	Read Data	Output	Level	Low	6.8 kΩ to +5, Output of 7417
48	TR	Input	Level	High	1 kΩ to +5, 5 TTL inputs 0.001µf
50	TRUN	Input	Level	High	One TTL input., 0.001µf to GND

NOTE: This connector is used only when the tape drive is supplied without the control card. The outputs are not directly bussable.

Table 2-4. Drive Assembly Pin Assignments

Connector and Pin	Signal Name	Input/ Output	Level/ Pulse	Active State
		OPTICAL TACH		
J3-1	Not used	-	-	-
J3-2	BULB ON 1	Output	Level	Fixed
J3-3	+12 Vdc Regulated	Input	Level	Fixed
J3-4	Gnd	Input	Level	Gnd
J3-5	Not used	-	-	-
J3-6	+Sync	Output	Pulse	Transition
J3-7	+5 Vdc	Input	Level	Fixed
		TAPE MARK SENSOR		
Sep. Pin	Servo Gnd (used on assy 786045 only)	Input	Level	Gnd
J4-1	+18 Vdc	Input	Level	Fixed
J4-2	BULB ON 2	Output	Level	Fixed
J4-3	Not used	-	-	-
J4-4	Logic Gnd	Input	Level	Gnd
J4-5	+12 Vdc	Input	Level	Fixed
J4-6	SEW	Output	Pulse	High
J4-7	SEOT	Output	Pulse	High
		SOLENOID		
J6-1	-18 Vdc	Input	Level	Fixed
J6-2	CIPX	Output	Level	Low
J6-3	FP	Output	Level	High
J6-4	Logic Gnd	Input	Level	Gnd
J6-5	Unload Switch	Output	Level	High
J6-6	USRDY (control only)	Input	Level	High
J6-7	Eject solenoid drive	Input	Pulse	+18 Vdc
		HEAT SINK POWER AMP		
J7-1	Gnd	Input	Level	Gnd
J7-2	+18 Vdc	Input	Level	Fixed
J7-3	-18 Vdc	Input	Level	Fixed
J7-4	Motor drive (feedback)	Output	-	Analog
J7-5	Drive to NPN base	Output	-	Analog
J7-6	Drive to PNP base	Output	-	Analog
J7-7	Not used	-	-	-

selected. This permits multiple drives to operate from the same bus.

2.9 TERMINATIONS

The input lines of the tape drive may or may not be terminated depending upon the option selected (table 1-2). Typical terminator resistors are shown in figure 2-6A. Check your order number for option supplied. When more than one unit is connected to the same bus, only the last one should be terminated.

2.10 UNIT SELECT CODE

The unit select code is used to select any one of up to eight tape drives operating from the same bus. Method of coding is accomplished on the control card and depends upon option selected (table 1-2). The unit select code may be factory wired (option 1S), selected using a Programming switch (option 2S), or wired by the user (option XS). If the unit select code had been factory wired, that code should be specified on the purchase order. If the unit select code can be selected by a Programming switch (fig. 2-7), the switch can be set according to table 2-5. If the unit select code is to be wired by the user, coding jumpers must be added to the control card. The jumpers are wired across the spot normally occupied by the programming switch. (Refer to table 2-6 and figure 2-8.)

2.11 AUTOMATIC LOAD CYCLE

Automatic Load cycle is enabled either by setting switch 1 (U13) on the control card (fig. 2-7 and table 2-5), if available, to ON or factory wired jumper across pin 1 and 14 (fig. 2-8 and table 2-6). If a tape cartridge is inserted in the drive with power on and Auto Load cycle selected, the cartridge will automatically rewind to BOT, then move forward at 30 IPS and stop at LP.

Normally the cartridge will not go into Auto Load cycle on power up with cartridge in the drive. If it is necessary that the cartridge go into Auto Load cycle on power

Table 2-5. Unit Select and Auto Load Programming via Switch

Address or function to be programmed	Switch settings (U13)						
	1	2	3	4	5	6	7
Unit Select Code 0		on	off	on	off	on	off
Unit Select Code 1		off	on	on	off	on	off
Unit Select Code 2		on	off	off	on	on	off
Unit Select Code 3		off	on	off	on	on	off
Unit Select Code 4		on	off	on	off	off	on
Unit Select Code 5		off	on	on	off	off	on
Unit Select Code 6		on	off	off	on	off	on
Unit Select Code 7		off	on	off	on	off	on
Auto Rewind Enabled	on						
Auto Rewind Disabled	off						

Table 2-6. Unit Select and Auto Load Programming via Jumpers

Function	Jumpers (Indicated by X)						
	1-14	2-13	3-12	4-11	5-10	6-9	7-8
Unit Select Code 0		X		X		X	
Unit Select Code 1			X	X		X	
Unit Select Code 2		X			X	X	
Unit Select Code 3			X		X	X	
Unit Select Code 4		X		X			X
Unit Select Code 5			X	X			X
Unit Select Code 6		X			X		X
Unit Select Code 7			X		X		X
Auto Rewind Enabled	X						

Note: Auto Rewind is independent of Unit Select Codes.

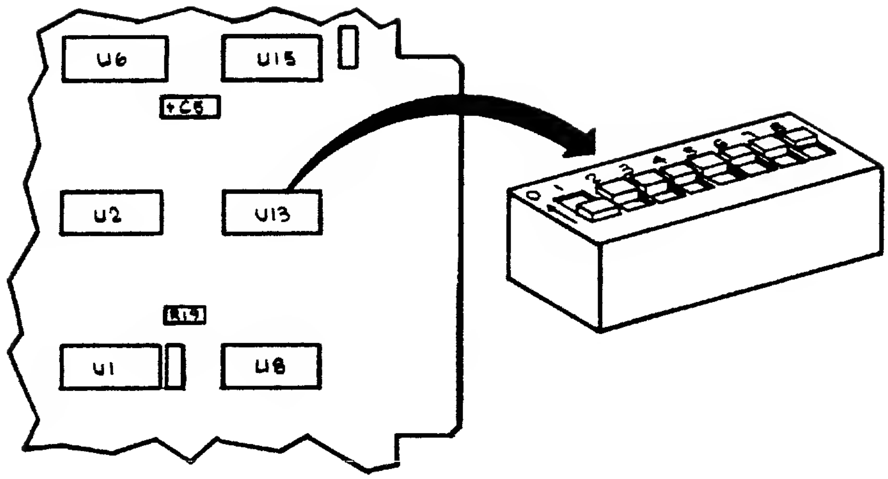


Figure 2-7. Unit Select and Auto Load Programming Switch

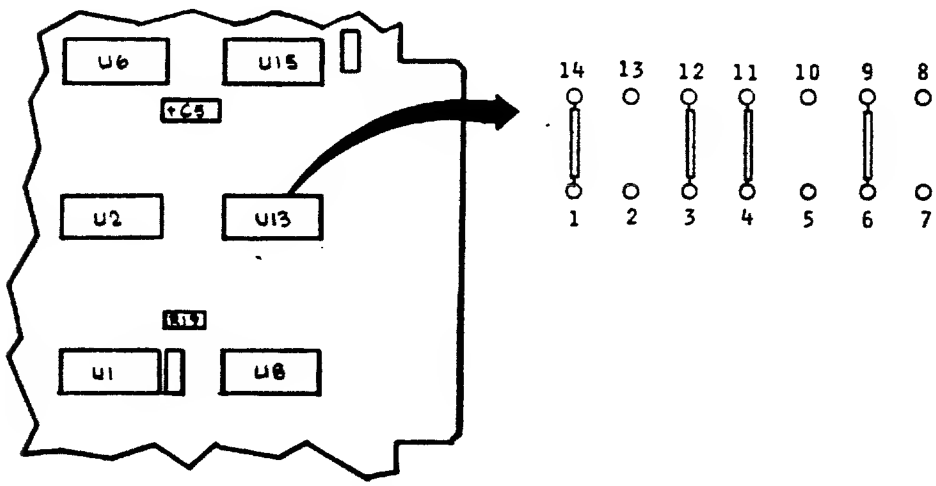


Figure 2-8. Unit Select and Auto Load Programming via Jumpers

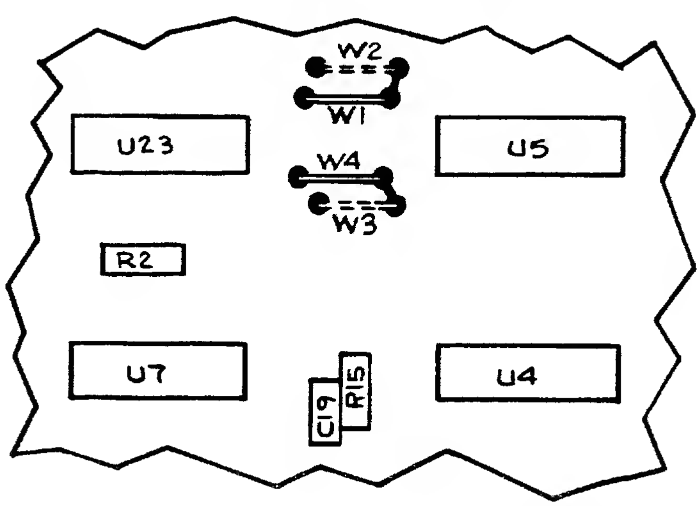


Figure 2-9. Auto Load Cycle on Power Up

up, cut jumpers W1 and W4 (fig. 2-9 solid lines) and install jumpers W2 and W3 (dashed lines).

2.12 TACHOMETER CLOCK

If a tape formatter (part no. 786700) needs clock pulses from the tachometer, remove jumper W5 on the control board and install jumper W6 (fig. 8-5).

2.13 JUMPERS ON OPTIONAL CONTROL BOARD

Control board with phase decoder circuit does not have an Eject command (connector J9-2). This pin is used to output a Data Present signal. If Eject command is desired and Data Present signal is not needed, cut land, on bottom-side, of PC board at W5 and install jumper, on top side, at W6 (fig. 9-6).

2.14 PACKING INSTRUCTIONS

Pack the tape drive as shown in figure 2-1. Place the unit in a cardboard box large enough for several inches of clearance between it and the sides and ends of the box. The tape drive should be suspended in the middle by foam pads at either end. Cardboard inserts, top and bottom, strengthen the box and minimize unpacking damage. Secure box with packing tape.

SECTION 3

INTERFACE SIGNAL DEFINITIONS

3.1 GENERAL

This section describes the control board and servo/data board I/O signals.

3.2 LOGIC CONVENTION

A signal voltage more negative than 0.4 volts is defined as logic 1 (true) and a voltage level more positive than 2.4 volts is defined as logic 0 (false). These logic levels are shown in figure 3-1.

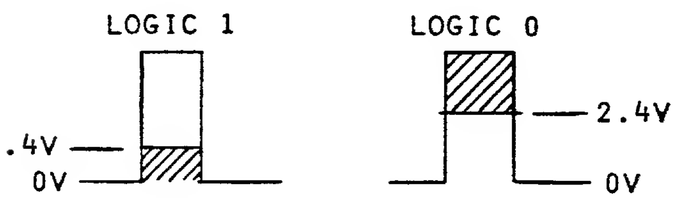


Figure 3-1. Logic 0 and 1

3.3 CONTROL SIGNALS

The control signals used to operate the tape drive are described in the following paragraphs. Associated pin numbers are listed in table 2-1.

a. Unit Select A, AX, B, BX, C, CX - The Unit Select lines are used to choose any one of up to eight tape drives. The lines represent three binary bits and their complements of address information. Three of these six will be used to decode a one-out-of-eight address. The tape drive must be selected to initiate any command, or to have its status signals or read data connected to the bus. Unit selection coding is:

Drive Selected	Unit Sel A	Unit Sel B	Unit Sel C
0	High	High	High
1	Low	High	High
2	High	Low	High
3	Low	Low	High
4	High	High	Low
5	Low	High	Low
6	High	Low	Low
7	Low	Low	Low

b. Rewind - A logic 1 on this line will initiate a high-speed rewind to BOT, followed by an automatic advance to Load Point. This line may be a pulse of at least 0.4 μS or a level removed upon detection of BOT. Once a Rewind is initiated, the Select command may be removed. The tape drive will automatically perform the entire rewind cycle.

c. Unload A - A logic 1 on this line will initiate a high-speed rewind to BOT, followed by an automatic ejection of the data cartridge. This line may be a pulse of at least 0.4 μS or a level removable upon detection of BOT. Once an Unload is initiated, the Select command may be removed. The tape drive will automatically execute the entire unload cycle.

d. Tape Run - A logic 1 on this line will enable tape motion at the selected speed and direction. A logic 0 inhibits tape motion. This line should not be used when performing a Rewind or Unload.

e. FWD/REV - A logic 1 on this line will cause the tape to move forward when Tape Run is applied. A logic 0 on this line causes the tape to move in the direction when Tape Run is applied.

f. Hi/Lo - A logic 1 on this line will cause the tape to move at high speed (90 ips), when Tape Run is applied. A logic 0 on this line causes tape to move at 30 ips.

g. Read/Write - A logic 1 on this line enables the write circuits if the data cartridge is not in Safe condition. A logic 0 inhibits writing. A tape drive with a dual gap head will always read regardless of the state of the Read/Write line.

h. Eject - A logic 1 on this line will cause an immediate data cartridge ejection if the tape drive is not in an unload cycle.

i. Track Select A and B - These two lines represent a one-out-of-four address number to select up to four tracks. Track selection coding is:

Track Selected	Track Select A	Track Select B
1	high	high
2	low	high
3	high	low
4	low	low

The tape drive can be supplied for 1, 2, or 4 track operation. Four track is standard.

3.4 STATUS SIGNALS

The status signals generated by the tape drive are described below. Associated pin numbers are listed in table 2-1.

a. Ready - A logic 1 on this line indicates the tape mark sensor and optical tach lamps are functioning, data cartridge is in place, and tape drive is selected.

b. Busy - A logic 1 on this line indicates the tape drive is performing an operation under internal control. Such operations are Rewind, Unload, Load, starting or stopping.

c. BOT - A logic 1 on this line incicates detection of the BOT hole pattern on tape. Detection of BOT, in any mode except Unload, will cause an automatic advance to Load Point.

d. EOT - A logic 1 on this line indicates detection of the EOT hole pattern on tape. Detection of EOT will cause forward tape motion to stop. The tape drive will then respond only to a reverse motion command.

e. Load Point - A logic 1 on this line indicates detection of the load point pattern on tape. This signal is maintained until the next Tape Run command is initiated.

f. Early Warning - A logic 1 on this line indicates detection of the early warning pattern on tape. This signal is not stored and is approximately 0.5 mS in duration at 30 ips.

g. File Protect - A logic 1 on this line indicates that the cartridge, in the tape drive, has its write plug in the safe position. Writing will be inhibited.

3.5 READ/WRITE DATA

The data input and output signals are described below. Associated pin numbers are listed in table 2-1.

a. Write Data - Write data is output data from the system to be written on magnetic tape using the data cartridge. The data must be phase encoded and in accordance with ANSI specification X3/B5/15. The data transfer rate of the tape drive is 48,000 bits per second (BPS). At the read/write speed of 30 inches per second (ips), the data transfer rate has a data density of 1600 bits per inch (bpi). Since the data is phase encoded, the 1600 bits are represented on tape by up to 3200 flux reversals.

b. Read Data - Read Data is that data read from the magnetic tape. It is the mirror image of the Write Data. If the magnetic head has a read-after-write capability, whatever is being written will be available as Read Data delayed by about 10 mS. The read delay of 10 mS is based on a distance of 0.3 inches between the write gap and the read gap of a read-after-write head at 30 ips.

3.6 ALTERNATE SIGNALS ON OPTIONAL DATA TRACKER CONTROL BOARD

The data input and output signals for the alternate control board are described below. Associated pin numbers are given in table 2-2.

a. Data Present - A logic 1 condition on this line indicates that data transitions have been detected on tape. This signal will terminate approximately 100 µS after the last transition is detected. This signal may be used for gap detection.

b. Data Valid - A logic 1 condition on this line indicates that a valid preamble has been detected and decoded data and data strobes will follow. This signal remains active as long as Data Present is active.

c. Decoded Data - This signal is an NRZ equivalent of the coded Read data. A low level indicates a 1 bit and a high level a 0 bit.

d. Data Strobe - This signal, in conjunction with Decoded data, can be used to shift data into a shift register. The data strobe is 2 µS wide and skewed 1 µS from the leading edge of Decoded Data. Data Strobes are valid only after the Data Valid signal is present.

3.7 TIMING

The timing of the I/O signals, required for the basic tape motion operations, is shown in figures 3-2 through 3-6. These diagrams illustrate the correct sequencing and relationship of the I/O signals. The basic tape operations can not take place until a tape drive has been selected.

3.7.1 Load (Fig. 3-2)

The load operation is performed when a data cartridge is inserted into the tape drive.

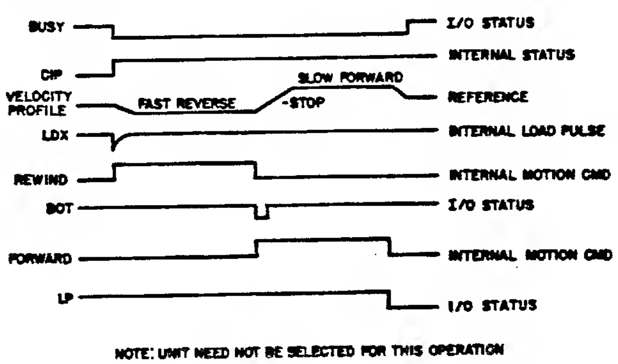


Figure 3-2. Cartridge Loading Operation, Timing Diagram

The timing diagram shows the signal sequence for the Auto Load option. The data cartridge is loaded, the Ready indicator lights, tape is rewound to a BOT mark and is then run forward to Load Point.

3.7.2 Write (Fig. 3-3)

Once the tape has been positioned at Load Point, data can be written. To write data, the tape must be moved (Tape Run) in the forward direction (FWD/REV) at 30 ips (Hi/Lo). The write circuits must be enabled (Read/Write and File Protect) and no internally controlled tape motion can be in process (Busy). When the tape is commanded to move, it accelerates to a velocity of 30 ips in 30±2 mS. While data is being written, the tape speed is held constant at 30 ips. After it has been written, the tape is allowed to move for another 10 mS so that the read head can complete the reading of the data. With single gap heads, the delay is not necessary. Tape is then decelerated to a stop in 30±2 mS.

NOTE

The time (30±2 mS), is derived from a timing circuit. Actually, the drive reaches the speed in about 25 mS and stops in about 15 mS. The start/stop distances for the tape drive thus differ.

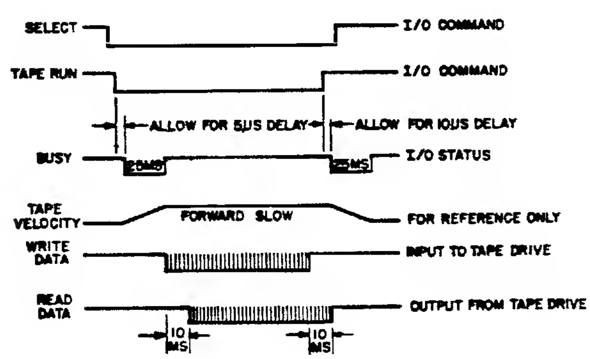


Figure 3-3. Write/Read Operation, Timing Diagram

3.7.3 Read (Fig. 3-3)

A read operation is similar to the write. Write circuits are disabled (Read/Write) and the file protect mechanism can be in either position (File Protect).

3.7.4 Fast Forward (Fig. 3-4)

For a fast forward operation, tape must be moved (Tape Run) in the forward (FWD/REV) direction at 90 ips (Hi/Lo). Tape is accelerated from stop to 90 ips in 75±5 mS, when Tape Run goes to a 1. Tape speed is maintained at 90 ips until Tape Run goes to a 0. Tape is decelerated to a stop in 75±5 mS .

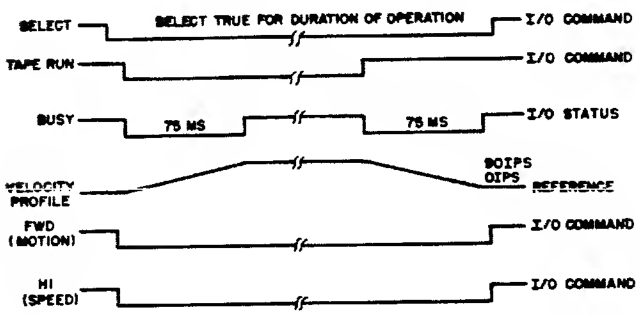


Figure 3-4. Fast Forward Operation, Timing Diagram

3.7.5 Rewind (Fig. 3-5)

A rewind operation (Rewind) rewinds tape to the BOT mark, and then advances the tape to the Load Point (LP). The operation is indicated by BUSY. Once rewind is initiated, the Select signal can be removed.

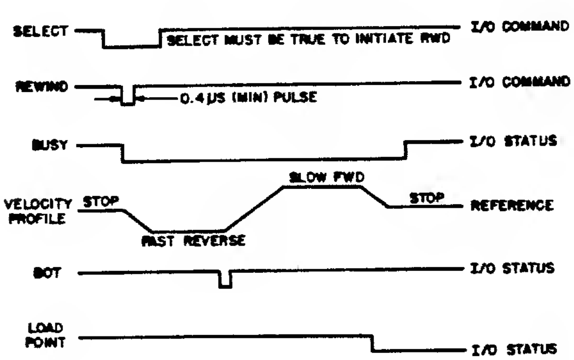


Figure 3-5. Rewind, Timing Diagram

3.7.6 Unload (Fig. 3-6)

An unload operation (Unload) rewinds tape to the BOT mark and then ejects the data cartridge. The operation is indicated by BUSY. Once unload is initiated, the Select signal can be removed.

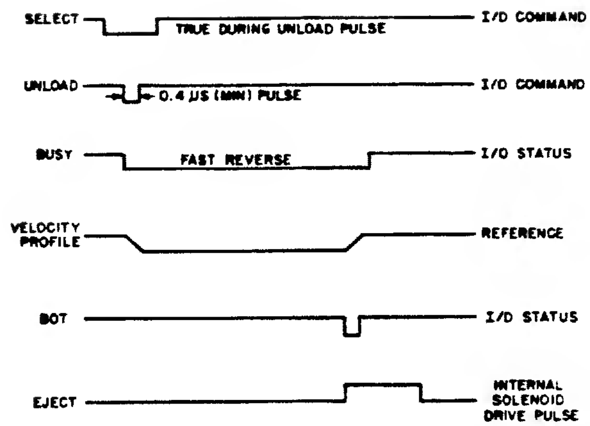


Figure 3-6. Unload, Timing Diagram

3.8 SERVO/DATA BOARD INTERFACE SIGNALS

The following paragraphs describe the signals appearing at J1 of the servo/data board (listed in table 2-2). The signals must be implemented when interfacing directly to the servo/data board (option 1PC).

a. USRDYX - This input signal should go active (low) when the unit is selected (on-line) and ready (Ready, pin 34, active).

b. FPX - This signal will be active (high) when the tape cartridge, within the drive, is not SAFE. When the drive has no cartridge, this output will be low (SAFE).

c. FASTAX - This input signal should go low for high-speed operation. For low-speed operation, this input should be high. This line must not change once tape motion has started.

d. FWDAX - This input signal should go low for forward direction of tape motion. Reverse direction is selected by setting FWDAX high. This line must not change once tape motion has begun.

e. Busy - This output signal will go high for the 30 mS period immediately following the application of TR (Tape Run) and the removal of TR when the drive is commanded to run at low speed. When operating at high speed, the pulse dura-

tion will be 75 mS. This output will also be high when REWUN is high.

f. RDYIX - This output signal is the complement of Ready and is used within the drive to illuminate the READY indicator.

g. CLKENX - This output signal goes low on the application of Tape Run and remains low for approximately 9 to 10 mS after the removal of Tape Run for 30 ips and 30 to 40 mS for 90 ips.

h. Unload SW - This output signal comes from an internal switch, sensing the depression of the UNLOAD push button. The other side of the switch is the USIX/UNLOADSW input (J1-28) driving the SELECT indicator. This switch can be used to set the unload function when the tape drive is not selected (not on-line).

i. USEJECTX - This input signal represents the Eject command to fire the solenoid, releasing the cartridge from the drive immediately. Energizing the solenoid occurs on the rising edge of USEJECTX.

j. REWUN - This input signal goes high during the entire Rewind or Unload operations. The REWUN command should be terminated when the Load Point is detected. Rewind is accomplished by causing the tape drive to move in the reverse direction at high speed.

k. LDX - This output pulse will occur when the data cartridge is inserted into the tape drive.

l. TMSB - This output pulse is approximately 10 mS in duration and occurs whenever either of the tape sensors detects a hole in the tape. This pulse allows the sensor outputs to be deskewed with respect to time.

m. FE - This input signal only has the effect of forcing BUSY true.

n. USIX/UNLOAD SW - This input signal drives the SELECT indicator and the switch linked to the UNLOAD push button.

o. STSP - This output is a high pulse of approximately 30 mS duration when the tape drive starts or stops at low speed. This pulse will be approximately 75 mS in duration when the tape drive starts or stops at high speed. This output is inhibited during Rewind or Unload.

p. Read/Write - When the tape drive is equipped with a dual gap head, it is always reading. This input signal is used to energize the write circuits. It also switches the read amplifier threshold from 10%, in write, to 5% in read. The servo/data board also contains the logic to inhibit writing in reverse. When the tape drive is equipped with a single gap head, this signal enables the read circuits when Read/Write is high.

q. Ready - This output signal will go high when a data cartridge is inserted into the drive and the tape mark sensor and optical tach light sources are functioning.

r. SEOTX - This output signal will go low when the lower sensor detects a hole in the tape.

s. SEWX - This output signal will go low when the upper sensor detects a hole in the tape.

t. Write Data - This input represents the phase-encoded data to be written on tape. During the gap, this signal should be high.

u. Track Select A - This input signal represents the least significant bit of the track select code.

v. Track Select B - This input signal represents the most significant bit of the track select code.

w. Read Data - This output signal represents the recovered phase encoded-data signal.

x. TR - This input signal is the Tape Run command and directly controls tape motion. When the direction and speed

commands have been set, the application of TR causes the tape to move. This movement will continue as long as this signal is true.

y. TRUN - This input signal fires the eject solenoid at the low-going edge. TRUN should go low when the BOT is detected during an Unload operation.

3.9 INTERBLOCK GAP

The minimum distance between successive block of recorded data is 1.2 inches. This means that the tape drive must be able to stop and start wtihin this length when writing or reading data. For example, for a write operation using a dual gap head, as the write gap completes the last byte of the Postamble, the read gap must still move 0.3 inches to complete the read-after-write operation. After the tape has been moved the additional 0.3 inches, the tape is decelerated to zero. Deceleration requires 0.12 inches. To start writing a new data block, the tape must be accelerated from zero to 30 ips. Acceleration requires 0.485 inches. Altogether the tape drive needs a gap of 0.905 inches, which is well within the required 1.2 inch minimum.

SECTION 4

OPERATION

4.1 GENERAL

This section contains information required to operate the tape drive.

4.2 CONTROLS AND INDICATORS

The controls and indicators of the tape drive are described in table 4-1 and illustrated in figure 4-1.

4.3 OPERATING PROCEDURE

4.3.1 Loading Data Cartridge

Load the data cartridge as follows:

NOTE

> Data cartridge is keyed and can be installed only one way. It should slide in easily.

a. Insert tape cartridge into mounting slot of tape drive (2, fig. 4-1), with metal plate toward UNLOAD button and status indicators.

b. Push cartridge in firmly until locked in place.

4.3.2 Unloading Data Cartridge

The data cartridge can be unloaded manually, remotely, or both, depending on the option supplied. Remote unloading is implemented by an Unload control signal described in paragraph 3.3, step c. To unload a data cartridge manually, proceed as follows:

a. Turn UNLOAD button one-half revolution clockwise.

b. Push UNLOAD button in until data cartridge is ejected half way.

c. Pull data cartridge straight out.

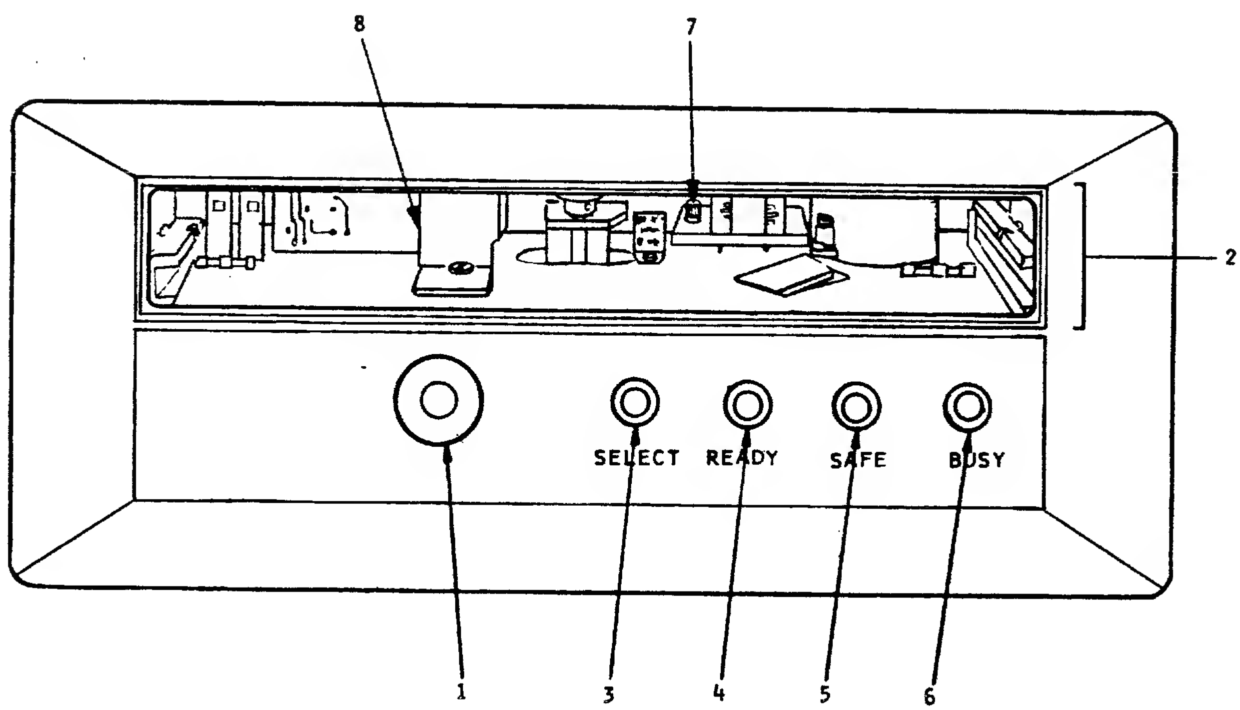


Figure 4-1. Controls and Indicators

Table 4-1. Controls and Indicators

Key No.	Name	Function
1	UNLOAD button NOTE UNLOAD button supplied with options 1E and 2E, but not 3E. Options 2E and 3E allow cartridge ejection by remote command.	Used to unlatch and eject cartridge manually.
2	Mounting slot	Mounting slot for data cartridge
3	SELECT indicator NOTE SELECT indicator supplied with options 1D but not 2D or XD.	Indicates tape drive has been selected by controller.
4	READY indicator	Indicates that data cartridge is loaded and TMS and Op Tach are functioning.
5.	SAFE indicator	Indicates when file protect plug of a loaded cartridge is in SAFE position.
6	BUSY indicator	Indicates when tape drive is performing an internal function such as Rewind, Start, Stop, Load, and Unload.
7	Tachometer Sensor (approximate location)	Part of optical tachometer which maintains precise speed control of tape drive.
8	Tape mark sensor	Solid state infrared emitters and sensors for detecting of BOT, LP, EW, and EOT holes.

4.4 CARTRIDGE RETHREADING

The tape within the data cartridge is not fastened to the reel hubs. Although there are safeguards built-in the Model 650, it is possible during system integrateion that due to erroneous connections the tape within the cartridge is wound off the reel hub. When the drive detects this malfunction, it locks out all motion thereby preventing damage to the tape. The cartridge is easily repaired by adhering to the following procedure (fig. 4-2).

a. Place the cartridge upside down on a flat surface.

b. Remove the four Phillips head screws.

c. With one hand holding the plastic cover stationary against the flat surface, use the other hand to carefully lift the

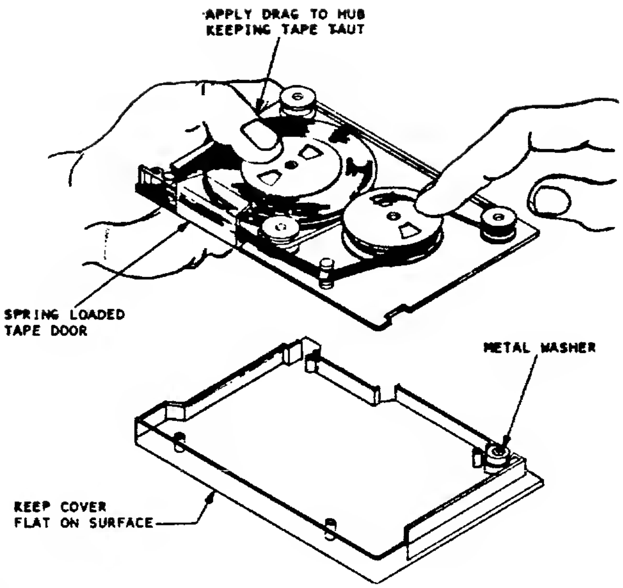


Figure 4-2. Rethreading Tape

metal plate upward and out of the palstic case. Do not dislodge the metal washer located on the Safe hub assembly or the spring loaded tape door on the deck plate.

d. Carefully thread the loose end of the tape through the tape guides.

e. Moisten the inside surface of the loose end of tape and apply to empty hub.

f. Using both hands, use one hand to apply a drag to the hub having the bulk of the tape and start winding the other hub to establish the pack. The tape should be taut.

g. Continue to wind the tape on the take-up reel by only rotating the take-up reel. Do not rotate the supply reel, i.e., the reel with the bulk of the tape.

h. Continue to wind the tape until three of the tape hole patterns have been wound up on the take-up reel.

i. Using caution, invert the metal plate and reinsert into plastic cover.

j. Replace the four Phillips head screws.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

This section contains theory of operation of the tape drive, which consists of two main printed circuit boards: control board and servo/data board. The control board is described to the schematic diagram. The servo/data board is mainly described to a block diagram.

5.2 CONTROL BOARD

There are two versions of the control board. Figure 9-6 shows the standard version of the control board and figure 9-7 shows the optional control board with data tracker circuits. The two assemblies are identical, except that the optional control board has circuits for phase decoding and provides decoded Read data.

5.2.1 Standard Control Board

The control board contains the logic required to interface the I/O command signals to the servo/data board and to perform several self-completing operations. The I/O signals are converted by the logic into those control signals required to read and write data, and to position tape. Additionally, the logic monitors the status of the tape and the data cartridge and generates I/O status signals.

The self-completing operations performed by the logic are (1) position tape at Load Point when a data cartridge is loaded (Load), (2) rewind tape to Load Point (Rewind), and (3) rewind tape to BOT and eject data cartridge (Unload). Once a self-completing operation has been initiated, it will be carried through to completion. Unit Select A, B, and C are required to initiate Rewind and Unload, but not Load. Load is initiated by insertion of a data cartridge. Generally, the transfer of all commands and status signals are enabled by the application of the correct unit select code.

The control board performs the following operations:

- Unit Select A, B, and C
- Load Cycle
- Tape Run commands
- Rewind Cycle
- Unload Cycle

NOTE

Unless otherwise indicated, the following discussion refers to figure 9-6.

5.2.1.1 Unit Select A, B, and C (Fig. 9-6, Sh. 1)

The unit select code for the tape drive is selected by the integrated circuit switch assembly U13, or jumpers which may be used in its place. The switch connects either Unit Select A or AX, B or BX, and C or CX to triple NAND gate U12. The letter X when used as the last letter of a mnemonic, denotes the complementary signal. One switch for each pair is closed to establish the code. When the Unit Select code at the closed switches consists of all true signals, the inputs to U12 are low and U12-6 goes high. The output of U12-6 is inverted by U14-6 and drives the SELECT indicator. In addition, the output of U12-6 is ANDed with the Ready signal by U18-3 to produce USRDYX and USRDY. USRDYX is used to enable all other I/O receivers and bus drivers.

5.2.1.2 Load Cycle (Fig. 9-6, Sh. 1)

The Load operation consists of moving tape in the reverse direction at high speed until a BOT mark is reached. At the BOT mark, the tape is stopped and then moved in the forward direction at low speed until Load Point is reached. At Load Point the tape is stopped to await the next I/O command signal.

A load operation is initiated whenever a

data cartridge is loaded and is independent of select. If BULB ON 1 and BULB ON 2 are true, RDYIX will go low (fig. 9-5, sh. 1). RDYIX is differentiated by C10 and the parallel combination of R29 and R33, resulting in a negative-going pulse (LDX). The negative-going LDX pulse starts from a DC level of about +3.5 volts. If switch U13 (pin$ 1, 14)(fig. 9-6) is closed, LDX will be coupled through U7 and OR gate U6 (pin 12) to AND gate U4 (pin 5). Since an unload operation is not being performed, TRUN is low, which is ANDed with LDX, resulting in a pulse which sets latch U5. The output of Rewind latch U5-4 (REW) goes to a high, forcing U4-1 (REWUN) to a high. Since STSPX is high, U6-3 also goes high.

LDX also clears DIREV latch U5-13 through gates U7-6 and U23-11. This initializes gate inputs U18-10 (DIREV) to be low and U18-13 (DIREVX) to be high. U6-3 going high, is thus able to preset latch U1-9 (FWDAX) and clear latch U1-5 (FASTAX) through gates U18-11 and U6-6. FASTAX low and FWDAX high is the condition for high-speed (90 ips) tape motion in the reverse direction.

Tape is moved in the reverse direction at high speed until BOT is reached. The upper BOT hole generates a SEW signal and the lower hole generates a SEOT signal. SEW and SEOT are delayed and inverted by U6- (fig. 9-5, sh. 1). The delay is used to remove noise spikes from the lines. SEWX and SEOTX are ORed by U6-8. Whichever occurs first triggers one shot U7, producing a TMSB pulse. TMSB lasts somewhat longer than either SEWX or SEOTX (approximately 10 mS).

The above three signals are used on the control board (fig. 9-6). TMSB goes high, enabling the clock inputs of the JK Master/Slave flip-flops U20-1 and U20-6. During the period when TMSB is high, the clock inputs are enabled, and SEWX or SEOTX going high will set the Master flip-flop. When TMSB goes low the condition of the Master will be transferred to the Slave and appear at the Q outputs U20-14 and U20-10. The function of U20 and TMSB is to deskew the sensed tape holes for BOT since the signals from the upper and lower sensors to not occur simultaneously. The resulting negative steps are ORed by U2-11 and delayed by R1, C3, and U3. The delayed negative going pulse is applied to U20-3 and U20-8, resetting both Q outputs. The result is the generation of two simultaneously occurring pulses (PEW and PEOT) each time the tape reaches a BOT mark.

On detection of BOT, the tape stops and moves forward at slow speed (30 ips). The low-going pulses (PEOTX and PEWX) generated by the detection of BOT, cause BOT flip-flop U11-15 (fig. 9-4, sh. 1) to set through gates U19-12 and U14-12. BOT (U11-15) going high, causes TR (U7-3) to go low through gates U19-6 and U15-8. When TR is cleared, the tape drive is commended to stop. TR goes to the servo/data board through connector J2-7 and fires one-shot U7 and U42 (fig. 9-5, sh. 1). This generates start-stop pulse STSPX. On the control board, STSPX and STSP are used by gate U16-11 (fig. 9-6, sh. 2) to generate a low-going pulse NESPX. NESPX sets DIRVE flip-flop U5-13 through gate U16-8. DIRVE going high, clears U1-9 (FWDAX) and presets U5 (FASTAX) through gate U18-8.

FWDAX low and FASTAX high is the condition for the drive to move in the forward direction at low speed. Since TRID and FWDA are now both high, U10-3 becomes low, clearing BOT flip-flop U11-15. This causes U19-6 to go high which in turn causes TR to go high. The tape now moves in the forward direction at low speed.

The tape moves forward until Load Point is encountered. This causes SEWX pulse to assert and U20-15 (PEW) is set while U20-11 (PEOT) remians low. This is decoded by gate U17-1 as EW. EW going high and DIREV being high, causes EWDIREV to go high. This presets LP flip-flop U11-11 through gate U10-11. The Load Point status (LPO) is outputted through gate U2-6. EW going high also resets Rewind flip-flop U5-4 through gate U18-6. REW going low, causes TR to go low through gates U6-3, U12-12, U14-4, U15-8, and U7-3, thus stopping the drive.

If a data cartridge is already in the tape drive and power is turned on, the drive

will go into a load cycle depending on jumpers W1, W2, W3, and W4 on the control board. If jumpers W2 and W3 are installed and W1 and W4 are omitted, the drive will go into the load cycle when powered up with data cartridge in the tape dirve. With jumpers W1 and W2 in and W3 and W4 out, the power-up reset circuit of the control board will reset all status flip-flops and there will be no tape motion.

5.2.1.3 Tape Run Commands (Fig. 9-6, Sh. 1)

When the tape drive receives a Tape Run command, and is Ready and not Busy, it will respond by moving tape in either the forward or reverse directions at either high or low speed. When a Tape Run command is received, the unit has been selected and Ready is true, U17-13 goes high, making both CCLK and TR go high. R16, C11, and U14-10 form a delay circuit which produces a positive pulse at U6-11. The pulse is inverted at U17-4 and NANDed with Busy at U12-8. If Busy is false, CCLK will be a positive pulse coincident with Tape Run. CCLK is applied to the clock inputs U1-3 and U1-11 of D flip-flops U1. FWD/REVX is applied to D input U1-12 and HI/LOX is applied to D input U1-2. When CCLK goes positive, whatever state is present at the D input is shifted to the corresponding Q output. As an example, if FWD/REVX is low and CCLK goes high, a low is transferred to U1-9 (FWDAX). Tape motion will be in the forward direction. Similarly, if HI/LOX is low, when CCLK goes high, a low is transferred to U1-5 (FASTAX), and tape motion will be at high speed. The direction and speed of tape motion will correspond to the status of the D inputs U1-12 and U1-2 as shown in table 5-1.

Table 5-1. Tape Direction and Speed

Direction and speed	FWD/REVX U1-12	HI/LOX U1-2
Forward/slow	Low	High
Forward/fast	Low	Low
Reverse/slow	High	High
Reverse/fast	High	Low

Simultaneous to the direction and speed settings, TR is also set by TAPERUNX when TAPERUNX goes low, U17-13 goes high, U12-12 goes low, U14-4 goes high, U15-8 goes high, and U7-3 (TR) goes high. Tape motion will commence as soon as TR goes high.

5.2.1.4 Rewind Cycle (Fig.9-6,Sh.1)

A rewind operation occurs when the tape drive receives a Rewind command. The tape is rewound to BOT and then advanced to Load Point. The Rewind cycle is similar to the Load cycle. The Load cycle was initiated by LDX, setting rewind flip-flop U5-4. The Rewind cycle is initiated by the Rewind command at gate input U4-1, setting Rewind flip-flop U5-4. The rest of the operation is similar to the Load cycle as described in paragraph 5.2.1.3.

5.2.1.5 Unload Cycle (Fig.9-6,Sh.1)

An unload operation can be initiated by either an Unload command or by the front-panel UNLOAD switch. (The tape drive can be supplied as an option with manual eject only, or controller eject only.) When an Unload command is received and the tape drive has been selected and is ready, U4-8 goes low, setting unload flip-flop output U5-9 high. Alternately, if the tape drive is not selected and the UNLOAD switch is depressed, U5-9 will again be set high (by way of U21-5 and 6, jumper A to B, and U5-11).

A high at U5-9 (TRUN) sets TR (U7-3), REWUN (U4-8), and FWDAX (U1-9) high, and FASTAX low. TRUN sets FWDAX high by way of U14-8 and U6-6, clearing the FWDA flip-flop. The same signal that cleared the FWDA flip-flop also sets the FASTA flip-flop, causing U1-5 to go low. These changes in status initiate tape motion at high speed in the reverse direction.

When the tape is rewound to the BOT mark, BOT goes true, driving U19-6 (REX) to low. REX resets the unload flip-flop output U5-9 (TRUN) to a low by way of U21-8, U23-8, and U5-10. TR (U7-3) goes to low, decelerating the servo to a stop. When TRUN goes to low, U4, on servo/data board (fig. 9-5, sh. 4), is fired. U4 output pulse is amplified by Q19 and Q14 and drives the eject solenoid. The eject solenoid releases the data car-

tridge, and allows the eject spring to drive the cartridge about halfway out of its compartment.

5.2.2 Optional Control Board

The optional control board (fig. 9-7) includes a phase decoder which removes the Preamble from a properly formatted record and provides NRZ data and strobe instead of phase-encoded data. Figure 7-2 provides the voltage and waveform data for this function. All other functions are identical to the standard control board described in paragraph 5.2.1.

5.3 SERVO/DATA BOARD

The servo/data board contains: servo amplifier circuits; read, write, and erase circuits; data and motion control logic; and the eject solenoid drive circuit.

5.3.1 Servo System

The servo system has been specifically designed to drive a data cartridge. A block diagram of the servo systems engaged with a data cartridge is shown in figure 5-1. The tape in the data cartridge is accelerated by the servo from 0 to 30 ips in 27±2 mS for read/write operations, and from 0 to 90 ips in 75±5 mS for fast forward and rewind operations. Once at speed, it is held constant by the servo until a command to decelerate is received.

5.3.1.1 Data Cartridge

Within the data cartridge the tape is moved by an ingenious mechanism consisting of a flat drive belt and a belt capstan. The path of the belt encircles the belt capstan and the two belt guide rollers, and leads around portions of the two tape winds. The winds are driven at their perimeters by the belt, but in opposite directions. Since the belt must move both perimeters at the same distance, the amount of tape being unwound from one wind must always equal that being wound onto the other. As a result, the two winds will stay wound with correct tension and no tape spillage over the lifetime of the data cartridge. The belt capstan has two drive surfaces with different diameters. One surface drives the belt. The other is driven by the rubber covered drive wheel of the servo. The ratio between the diameters of the capstan drive surfaces is 0.76. As a result, the tape speed will be 0.76 of the peripheral speed of the servo drive wheel.

The servo drive wheel is driven by the servo motor by way of a timing belt, and with a 1:1 speed ratio. The use of the belt allows the servo drive wheel to be mounted on a spring-loaded pivot. As a data cartridge is loaded, the belt capstan pushes the drive wheel back a short distance. This spring loads the drive wheel against the capstan, providing the friction necessary for the drive to operate.

5.3.1.2 Control Signals

The servo moves in response to motion control signals. These commands are generated by the motion control logic (fig. 9-5, sh. 1) in response to commands received from the control board (fig. 9-6). They consist of CLKEN, CLKENX, TR, FAST, SLOW, FWD, and FWDX described below.

a. CLKEN is made up of tape run (TR) plus an 8 to 14 mS delay. It allows tape motion circuits to decelerate tape motion after TR goes false (stop time) dynamically.

b. CLKENX is the negation of CLKEN.

c. TR is the Tape Run command. TR comes from the control board. When TR goes true, tape is accelerated to speed and maintained there. When TR goes false, tape is decelerated to zero.

d. Fast (true) commands the servo to operate at 90 ips. The Fast command comes from the control board. At I/O connector it is called Hi/Lo. When Fast is true, Hi/Lo is true.

e. Slow is the negation of Fast and is listed as FASTAX.

f. FWD true commands the tape drive to move tape in the FWD direction, and FWDX in reverse. FWD is derived from FWD/REV at the I/O connector. FWD/REV true generates a FWD tape motion command.

5.3.1.3 Operation (Fig. 5-1 and 9-5)

Before tape motion can be initiated, tape speed and direction must be established. This requires a Fast or Slow and a FWD or FWDX motion command from the control board. When a TR command is applied, tape will be moved in the prescribed direction. For example, when Slow and FWD are ture and TR goes ture, the tape will be accelerated to and maintained at 30 ips in the forward direction.

When TR goes true, driver U15 moves FET switch Q10 into conduction. The FET switch clamps the inverting input of U25 to the clamp voltage set by potentiometer R116. The gain of U25 is -1. Whatever voltage (typically -2 volts) is set by R116 will appear as a positive one (typically +2 volts) at the output of U27 (also the output of the clamp block in figure 5-1).

The positive step at the output of the clamp allows ramp generator U24 to start charging in a positive direction. The output of the ramp generator is fed back to its input where it is compared to the clamp voltage. When the ramp voltage equals the clamp voltage, charging will stop, and the output voltage of the ramp generator will remain fixed. This output voltage level is set by R116 and is used as a reference voltage for the servo.

As the ramp voltage goes positive, it is compared to the feedback voltage from the tachometer by operational amplifier U24 (pin 2).

When the two voltages are equal and opposite, the output of U24 (pin 1) is zero. Initially, the tachometer is at rest and the voltage at TP7 is zero. U24 has a high gain. A large offset voltage quickly develops at its output. This offset is amplified by the servo amplifier, applied to the servo motor, and used to overcome the high static friction of the data cartridge.

After about 5 mS, the servo motor starts to turn, accelerating rapidly to catch up with the ramp. The tachometer circuits generate a voltage proportional to the velocity of the servo motor. This voltage is of negative polarity, and is observed at TP7. When compared with the ramp at TP9 by U24, it reduces the input of U24 towards virtual ground. Initially, the voltage at TP7 lags the voltage at TP9 by about 5 mS. At 20 mS the ramp at TP9 reaches the voltage set by R116 and becomes fixed at about 2 volts. At 27 mS, the voltage at TP7 reaches a magnitude sufficient to reduce the voltage at the input of U24 to virtually zero. (Virtual zero is defined as that very small voltage at the input of U24, which, when amplified, will produce the voltage required to operate the servo motor at either 30 ips or 90 ips.)

Once at speed, it is held constant. If the servo motor slows down, the tachometer output drops. The negative tachometer voltage at TP7 drops. The difference between the command voltage at TP9 and the tachometer voltage at TP7 is detected by U24. The difference voltage is amplified by U24 and the succeeding amplifiers. The voltage across the servo motor is increased and the motor speed corrected back towards a value corresponding to the command voltage at TP9. Conversely, if the motor speed should increase, it will be corrected to maintain a tape speed of 30 or 90 ips.

5.3.1.4 Tachometer Operation

The tachometer circuit generates a voltage proportional to motor speed. When the motor and tachometer are at a desired speed, the voltage at TP7 should be about -2 volts. Depending upon the gain of the tachometer citcuits, the -2 volts can be produced by a wide range of motor speeds. In the tape drive, the gain of the tachometer circuit is adjusted by potentiometers R100 and R113. R100 is adjusted for a tape speed of 90 ips, and R113 for 30 ips. The output of the circuit associated with R100 is selected

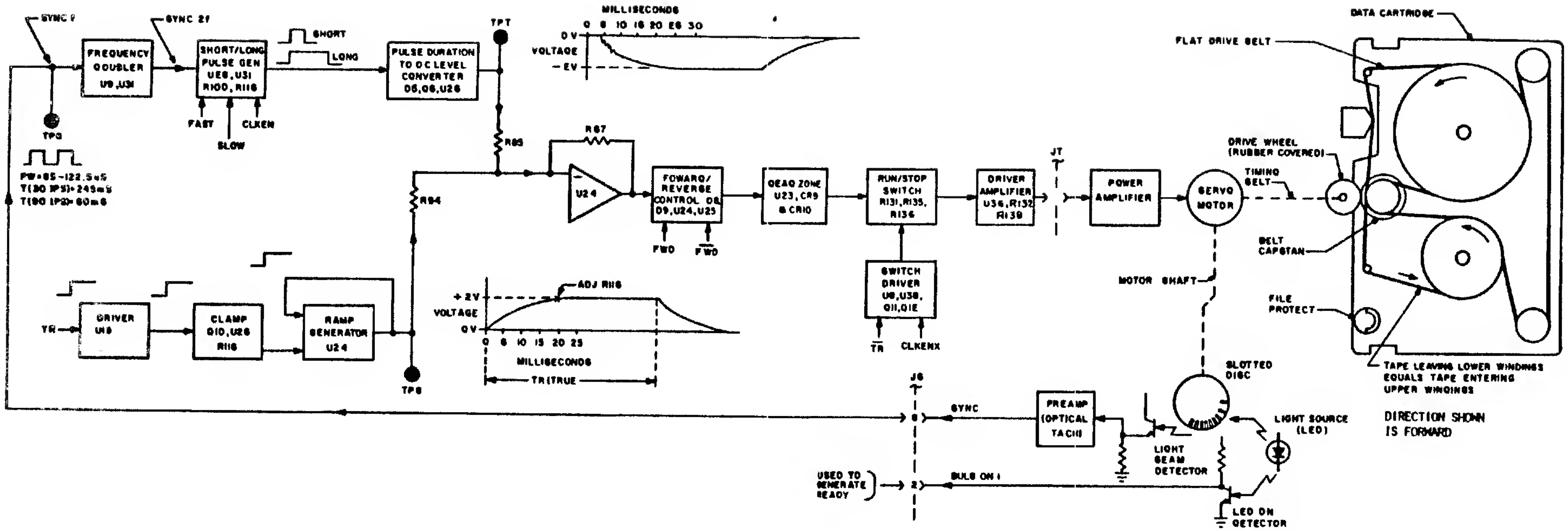


Figure 5-1. Servo System, Block Diagram

when Fast is true, and R113 when Slow is true. The tachometer circuit provides both speed adjustment and a selection of two speeds using motion commands.

The tachometer uses optical techniques. A slotted disc is directly connected to the servo motor shaft. The slots on the disc are alternately transparent and opague. The slots of the disc interrupt the light path between the lamp and a photo-transistor. As the disc is turned, the alternations in intensity appear as pulses at the collector of the photo-transistor. The pulses are amplified by the preamplifier (Q3, Q17, and Q4). The gain of the preamplifier is high, driving its output from 0 to +5 volts and providing a reasonably sharp rectangular waveform at TP8. The symmetry of the waveform is guaranteed by the comparator circuit and the selected hysteresis.

The preamplifier drives frequency doubler U9 and U31. The frequency is doubled by the frequency doubler's generation of a pulse for obth the leading and trailing edges of the rectangular waveform at TP8. The output pulses are short in duration, and are used to trigger the short/long pulse generator.

The short/long pulse generator contains two one-shot multivibrators, both are enabled by CLKEN. When enabled, they are continuously triggered by the pulse train. The output of the short-pulse one-shot is a train of 4 µS (approximately) pulses. The output of the long-pulse one-shot is a train of 15 to 20 µS (approximately) pulses. When the Fast motion command is true, the 4 µS pulse train is selected and drives the succeeding circuit. When the Slow motion command is true, the 15 to 20 µS pulse train is selected.

The pulse duration to the DC level circuit is essentially an RC filter network which filters the pulses to a dc level. Both pulse trains must result in a dc output level of -2 volts. For the 4 µS pulse trains to have the same dc level as the 15 to 20 µS, the 4 µS pulse train must have a higher frequency. This frequency results when the optical tachometer turns at a higher rate. To set up tape speeds, the pulse width from U26-13 is adjusted by R100 until the tape speed is 90 ips. The pulse width from U26-5 is adjusted by R113 until the tape speed is 30 ips.

5.3.1.5 Servo Amplifier

The servo amplifier starts with U24 and includes all of the stages through the power transistors to the servo motor. Besides amplifying the error output voltage from U24, the servo amplifier is used to command forward (FWD) or reverse (FWDX) tape motion, and to interrupt the servo loop. (See fig. 9-6, sh. 2).

Forward or reverse tape motion is established by the FWD/REV control block (U24, U25, Q8, and Q9). U24 and U25 are amplifiers and Q8 and Q9 are FET switches. U24 has a gain of 10. U25 has a gain of 1 and inverts the output of U24. When FWD is true, Q9 connects the output of U24 to the succeeding block, enabling forward tape motion. When FWDX is true, Q8 connects the output of U24 to the succeeding block, enabling reverse tape motion.

A dead zone, generated by U23, CR9 and CR10, makes the system unresponsive to small shifts in dc levels near ground reference. U23 is an amplifier which drives the two diodes. These two diodes are connected in parallel and end-to-end. They offer a large resistance to small voltage changes near ground reference. For large drive signals, their resistance becomes insignicant. This makes dc offset adjustment of the servo amplifier unnecessary.

Run/stop switch R135, Q12, and R131 shorts the input of the servo amplifier to ground when tape is not in motion. It is off, allowing tape motion, when either TR or CLKEN is true. It is on, stopping tape motion, when both TR and CLKEN are false. The circuit functions simply by shorting the signal at the intersection of R135 and R131 to ground using FET switch Q12. When TR goes false and tape is decelerated, CLKEN stays true and allows it to be decelerated according to the ramp at TP9. When the tape

has almost stopped, CLKEN goes false, shorting R135 and R131 to ground. Tape is then stopped completely by the low output impedance of the power amplifier and the high friction of the data cartridge.

U36, R132, and R138 provide the drive required by the power amplifier. The power amplifier consists of two power transistor packages mounted on the heat sink assembly. Each power amplifier package contains a Darlington amplifier. The two Darlington amplifiers are connected to form a complementary power amplifier. The output of the power amplifier is connected to one side of the servo motor. The other side of the servo motor is connected to ground, through a 1-ohm power resistor.

5.3.2 Read/Write Circuits

Figure 5-2 illustrates the functions performed by the read/write circuits of the tape drive. The write circuits accept data, phase encoded by a data formatter, and write that data on tape. The read circuits read the phase-encoded data recorded on tape, apply a noise margin to the signals, and produce data as a phase-encoded pulse train.

5.3.2.1 Write Functions

Data is written serially on only one track at a time. The track is selected by the two binary code signals (TRACK SELECT A and TRACK SELECT B). These two lines are decoded by the Track Decoder which enables one of the four track enable lines. Each enable line controls a pair of drivers used to drive a data recording head, and (if supplied) an erase head. Write data is connected to all of the write drivers at the same time, but data is written only by the enabled pair. Each driver pair receives in-phase and out-of-phase data. One of the drivers is normally on, driving one winding of its associated magnetic head. The resulting magnetic field produces a north-seeking pole at the beginning of the tape. When the write data line changes state, the other driver is turned on and the magnetic [illegible] recorded on the tape is reversed.

Before data can be written, the write and erase heads must receive a second enable. This enable states that the tape drive should write, and is in condition to write data. The enable is true when the tape drive is Ready, power supply voltages are OK, File Protect X is true, and the Read/Write (R/W) command is true.

5.3.2.2 Read Functions

The read circuits are always enabled when the tape drive is supplied with a dual gap head. When supplied with a single gap head, the read circuits are enabled only when the R/W command is low. The track to be read is enabled in the same way and at the same time as the write heads. When using a dual gap head, the circuit arrangement allows data to be read just after it is written (read-after-write).

Data read from an enabled track is amplified by high-gain amplifier U12 and U16. The output of U16 is split into two paths and then recombined by U5. The purpose of these circuits is to reject spikes and low-level signals defined as noise.

The signal is compared by U14 to one of two threshold levels. One level (5% of the peak signal) is used when reading data. A higher level (10%) is used during read-after-write operations. The higher level assures that the data can be read later on with a level of 5%. The timing diagram on figure 5-2 shows the waveforms associated with threshold circuits. The threshold detect output signal is applied to the J input of JK flip-flop U5. It is also inverted and applied to the K input.

In the lower branch, zero-cross-over circuit U14 detects a crossing through zero signal. Its output results in a square wave. The leading and trailing edge of the square wave are used to trigger one-shot U42. The 200 nS waveform is applied to the clock input of JK flip-flop U5. If the J input to U5 is a high and K is a low, when CLK goes low, the Read Data signal will go low. The output waveform is phase encoded, and a near image of that originally recorded on tape.

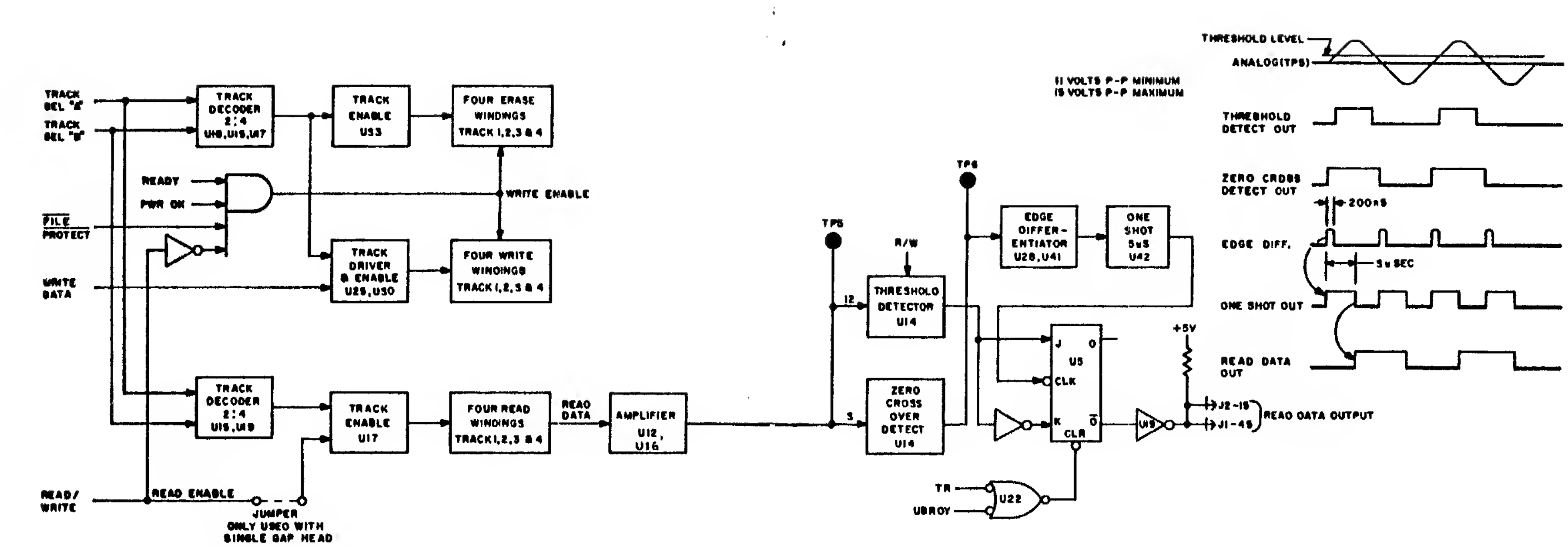


Figure 5-2. Read/Write Circuits, Block Diagram

5.3.3 Control Circuits

The servo/data board generates a number of commands based on the status of the drive mechanism and the commands received from the control board. These commands are used by the servo, the eject solenoid, and the read/write circuits.

5.3.3.1 Servo Commands

Commands required by the servo are TR, CLKEN, FAST, SLOW FWD, and FWDX. Each is described below.

a. TR Command (Fig. 9-5, Sh. 1) -
Tape Run (TR) is generated on the control board. It is used on the servo/data board to initiate the servo start ramp, and is a logic term used to generate CLKEN and STSPX.

b. CLKEN Command (Fig. 9-5, Sh. 1) -
CLKEN enables the tachometer circuits and the start ramp. When TR goes false, CLKEN extends the stopping time of the servo so that the stop ramp can be applied. CLKEN is generated by TR, TRX, and FASTAX. FASTAX selects one of two time constants for monostable multivibrator U4. When FASTAX is true, U3-8 is low and U1 is on. This places R7 in parallel with R10, causing the short delay of 8 to 14 mS required by the slow speed stopping ramp. When FASTAX is false (low), U1 is off and only R10 is left in the circuit. This results in the longer delay time required by the high-speed stopping ramp. The circuit operates as follows: When TRX goes false (Tape Run), U5 is set and U5-Q (CLKEN) goes high. At the end of Tape Run when TR goes false, monostable U4 is set. U4-Q goes true for the period established by C1, R7, and R10. At the end of its on period, U4-Q goes low, clocking U5. When U4-Q goes low, it is transferred at U5-J to U5-Q, and CLKEN goes to low (false).

Fast and Slow (Fig. 9-5, Sh. 1) -
Slow is equal to FASTAX. Fast is the negation (U3) of FASTAX.

d. FWD and FWDX (Fig. 9-5, Sh. 1) -
FWDX is generated on the control board. FWD is the negation (U3) of FWDX.

5.3.3.2 Eject Solenoid (Fig. 9-5, Sh. 4)

Eject Solenoid drive is a pulse derived from TRUN and USEJECT X and one-shot U4. The pulse is generated when USEJECT is high and TRUN goes from a high to a low. The pulse also results when TRUN is low and USEJECT X goes from a low to a high. TRUN is used with the control board as follows. When the tape drive receives an Unload command, TRUN goes high while rewinding to BOT and then goes low, ejecting the data cartridge. USEJECT is a user input and is usually high. Q16 is used to prevent ejection during power-up and power-down.

5.3.3.3 Read/Write Control Signals

Signals required by the Read/Write circuits are TR, USRDY, USRDYX, R/W, R/WX, TRACK SEL A, TRACK SEL B, WRENA, AND File Protect X.

a. TR (Fig. 9-5, Sh. 2) -
TR is used as an enable by the read circuits. TR is ORed with USRDY by U22. U22 enables JK flip-flop U5 by removing reset.

b. USRDY and USRDYX (Fig. 9-5, Sh. 2 and 4)-
USRDYX is generated on the control board and is the negation (U21) of USRDYX. USRDY is used with TR (as described in the preceding paragraph) to enable Read Data. USRDY is also ANDed with R/WX to generate an enable for erase head drivers U33.

c. R/W and R/WX (Fig. 9-5, Sh. 1,2, and 4)-
R/WX results from ANDing FWDX, Read/Write, and REWUN. When these signals are low, U2-8 (R/WX) is high. R/WX is ANDed with USRDY as described in the preceding paragraph to enable the erase heads. When a single gap recording head is used, R/WX functions to disable decoder U18 when writing data. R/W is also used to vary the threshold level of the read circuits between a read and a read-after-write operation.

d. Track Sel A and B (Fig. 9-5, Sh. 2)- These signals are generated on the control board. They are applied to decoders U18 and U20 and select the track for data to be written on or read from.

e. WRENA (Fig. 9-5, Sh. 4) - WRENA is the product of R/WX and ENA. When these two terms are true, U22-11 is high and WRENA is true. WRENA is used to enable track decoder U18 (Sh. 2) during a write operation.

f. File Protect X (Fig. 9-5, Sh. 1 and 4)- File Protect X is the negation of FP. FP is generated by a switch on the drive mechanism which senses the position of the file protect drum on the data cartridge. File Protect X is ANDed (Sh. 4) with WRENA by U22-8. The product is ANDed again with PWR ON (U40-8). The final product is used to enable the write and erase heads when: (1) the power supply voltages are OK, (2) File Protect is not enabled, (3) data is to be written, and (4) the tape drive is ready and selected.

5.3.3.4 Other Signals (Fig. 9-5, Sh.1)

Several other signals are generated by the servo/data board which are used by the control board. These are SEWX, SEOTX, TMSB, STSPX, AND Busy.

a. SEWX - SEWX is the negation of SEW. The leading edge of SEWX is delayed with respect to that of SEW by R27, C9, and U6. SEW goes true whenever an upper hole, in the tape, is detected such as BOT, Load Point, or Early Warning.

b. SEOTX - SEOTX is the negation of SEOT. The leading edge of SEOTX is delayed with respect to the leading edge of SEOT by R32, C11, and U6. SEW goes true whenever a lower hole, in the tape, is detected, such as EOT or BOT.

c. TMSB - Tape Mark Strobe (TMSB) is used to mask skewing of the tape marks. It is a pulse generated by U7. When CIP is true, U7-1 is low. If either SEW or SEOT goes true (any tape mark sensed), U7 will generate a pulse (TMSB). TMSB is used by the control board and is approximately 10 mS.

d. STSPX - The Stop/Start pulse (STSP) is generated by U7. U7 generates a pulse whenever TR goes true or false. The duration of the pulse is 30 or 75 mS corresponding to whether Fast is true (high) or false (low). The pulse duration is determined by either U7-5 or U42-5. STSP is used to generate Busy. STSP and STSPX are also used by the control board.

e. Busy - Busy is the product of STSP and REWUN. Busy indicates that the tape drive is performing either a start, stop, or rewind operation. Busy is used by the control board.

SECTION 6

MAINTENANCE

6.1 GENERAL

This section contains periodic maintenance such as cleaning, inspection, performance test, and calibration procedures of the tape drive.

6.2 CLEANING

The following paragraphs provide cleaning instructions for the various components of the tape drive. Refer to table 6-1 for cleaning intervals.

Table 6-1. Preventive Maintenance Schedule

Operation	Paragraph	Interval
Clean magnetic head	6.2.1	8 hours
Clean drive wheel	6.2.2	Weekly
Clean tachometer	6.2.3	Monthly
Clean tape drive	6.2.4	Semi-annually
Performance test	6.4	1000 hrs. operation
Replace motor		5000 hrs. run time
Inspect	6.3	Semi-annually

6.2.1 Magnetic Head

After eight hours of use, clean as follows:

CAUTION

> Do not use magnetic devices near the tape head. Do not touch the tape head with metal or other hard objects. Doing so may damage the head, resulting in tape cartridge damage and causing loss of data.

a. Inspect the tape head by shining a small light, such as a penlight, at an angle across the head surface. Look for accumulated foreign matter or damage to the head.

b. If the head is dirty, continue with this proceudre. However, if the head is damaged or worn, it should be replaced.

c. To clean oxide and accumulated foreign matter from the head surface, use a cotton swab moistened with isopropyl alcohol or a spray of Freon TF. Light oxide accumulations are readily removable. Heavy, or long-term, accumulations may require more cleaning, with more alcohol or Freon TF and clean swabs. Use extreme care when cleaning the head to prevent scratching or damaging the head surface.

d. After removing all accumulated material, use a clean, dry cotton swab to remove residue and polish the head.

6.2.2 Drive Wheel

Weekly, or approximately after 40 hours of tape run time, clean the rubber-covered wheel driving the data cartridge capstan as follows:

a. Dampen a clean cloth with isopropyl alcohol or trichloroethane.

b. While holding the cloth against the rubber-covered wheel, turn the wheel by moving one of the drive belt pulleys. Carefully clean all residue from drive wheel.

6.2.3 Tachometer

Visual inspection of the optical tachometer disk should be performed once a month. If the disk shows dirt or fingerprints, it should be cleaned with a soft moist cloth.

If unit has a stainless steel tachometer disk, instead of a mylar disk, it should

be cleaned by brushing or blowing air across surface where slots are. Be sure to remove any accumulated dirt or dust from the open areas. Excessive accumulation of dirt will cause speed stability problems.

6.2.4 Tape Drive

a. Remove tape drive from equipment. Disconnect I/O and power cables.

b. Clean bezel.

c. Carefully vacuum or blow dust from top surface of tape drive.

d. Place tape deck on its right side. Remove four screws holding circuit boards in place. Remove circuit boards and lay them flat on the bench.

e. Carefully vacuum or blow dust from circuit boards and underside of drive assembly.

f. Reassemble boards to drive assembly.

6.3 INSPECTION

Every six months of operation perform the following inspection:

a. Inspect drive belt and pulleys for wear. Replace worn components.

b. Turn capstan pulley through several full revolutions and check for:

(1) Smooth and somewhat stiff motion

(2) Bearings neither squeak nor give off binding sounds

6.4 HEAD WEAR AND REPLACEMENT

The head should be checked visually for secure mounting and for wear. Check the head crown to be sure it is not worn down, eliminating the depressed area between the read and write gaps. Head replacement requires precision alignment which can be done only at the factory. If the head needs to be replaced, return the tape drive to the factory.

6.5 PERFORMANCE TEST AND CALIBRATION

The performance tests given in table 6-4 are used for two purposes. First, they are used with preventive maintenance to assure correct operation. Second, they are used for corrective maintenance, providing a systematic guide for isolating malfunctions. Along with each check, a calibration and/or troubleshooting procedure is listed. If a parameter is out of specification, perform adjustment procedures. If a parameter cannot be corrected by adjustment, or had obviously malfunctioned, perform troubleshooting procedures. Table 6-2 lists the test equipment required to maintain the tape drive. Table 6-4 provides the following tests:

Test	Table 6-4
Power supply voltages	Step 1
CIP and Safe switches	Step 2
Status Logic	Step 3
Servo	Step 4
Servo stop	Step 5
Control	Step 6
Read/Write	Step 7
Motor	Step 8

Table 6-2. Test Equipment

Item	Equipment
1	Oscilloscope with two channels, 15 mHz bandwidth or greater, gain to 10 mV.
2	Two 1X probes
3	Digital counter
4	Digital voltmeter
5	Data cartridge pre-recorded with 1's on all four tracks

The performance test requires that the signals listed in table 6-3 be applied to J9 of the control board. These signals can be generated by the user's system or by a test set. If the system is used, it must be programmed to provide the signals in table 6-3. If a test set is assembled, the signals can be provided using high/low switches and several pulse/square wave generators.

Table 6-3. Test Control Signals (J9, Figure 9-6)

I/O signal name	I/O connector (J9 pin nos)	Signal status for different control functions									
		1 SEL STOP	2 FWD/ REV	3 FWD/ SLO	4 FWD/ FAST	5 WRITE TRK 1	6 REWIND	7 WRITE TRK 2	8 WRITE TRK 3	9 WRITE TRK 4	10 UN-LOAD
A AX B BX C CX	14 12 10 8 6 4	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1
TAPERUNX	24	H	Note 4	L	L	L	H	L	L	L	X
RWNDX UNLD AX UNLD BX	26 28 50	H H H	H H H	H H H	H H H	H H H	L H H	H H H	H H H	H H H	X L H
FWD/REVX	30	L	Note 5	L	L	L	X	L	L	L	X
HI/LOX TRK SEL A TRK SEL B RD/WRT	38 42 44 48	H H H H	H H H H	H H H H	L H H H	H H H L	X X X X	H L H L	H H L L	H L L L	X X X X
WRT DATA (Note 6)	40					All 1's		All 1's	All 1's	All 1's	X

Notes:
1. Address lines as required to select drive.
2. Address not selected.
3. 10 Hz square wave.
4. 5 Hz square wave synchronized to negative-going edge of preceding 10 Hz square wave (Note 3).
5. X indicates don't care state (either H or L).
6. All ones write data may be approximately by a 48 kHz square wave.
7. H = High; L = Low

Table 6-4. Performance Tests

Step	Procedure Indication Corrective action
1	POWER SUPPLY VOLTAGE CHECK
a.	Apply system power. Check for the following voltages on servo/data board (fig. 9-4, sh 2): (1) +12±0.48 V at emitter of Q1 (2) -12±0.48 V at emitter of Q2 (3) -5.2±0.2 V at pin 5 of U12 (4) +5±0.25 V at pin 10 of U12 (5) -6.8±0.2 V at pin 14 of U14 Perform troubleshooting procedure of table 7-1.
2	CIP AND SAFE SWITCHES CHECK
a.	Turn power to tape drive off.

Table 6-4. Performance Tests (Continued)

Step	Procedure	Indication	Corrective action
b.	Insert data cartridge.	CIP and Safe switches are engaged and data cartridge does not hit switch housing.	Perform calibration procedure of paragraph 6.6.1.
c.	Turn on system power.		
3	STATUS LOGIC CHECK		
a.	Apply (select stop) test control signals to J9 of tape drive per table 6-3, column 1.		
b.	Eject data cartridge by placing low-level signal on J9-2.	Only SAFE and SELECT indicators light.	Perform troubleshooting procedure of table 7-2.
c.	Depress Safe switch (fig. 6-1).	SAFE indicator goes off.	Perform troubleshooting procedure of table 7-2.
d.	Depress CIP switch (fig. 6-1).	READY and BUSY indicators light and servo runs at high speed (90 ips) reverse.	Perform troubleshooting procedure of table 7-2.
4	SERVO CHECK		
a.	Eject data cartridge (if in place), per step 3b.		
b.	Remove belt (if not already removed from preceding test).		
c.	Apply power.		
d.	Press CIP (fig. 7-1) switch.	Servo motor runs at high speed (90 ips) in reverse.	Perform troubleshooting procedure of table 7-3.
		Voltage at TP9 on servo/data board (fig. 9-5, sh. 3) is approximately 2 Vdc and inflection point is 20 mS.	Adjust R116 on servo/data board for proper reading at TP9. Perform troubleshooting procedure of table 7-3.
e.	Connect oscilloscope to TP8 on servo/data board.		
f.	Press CIP (fig. 7-1) switch.	The following waveform is observed.	

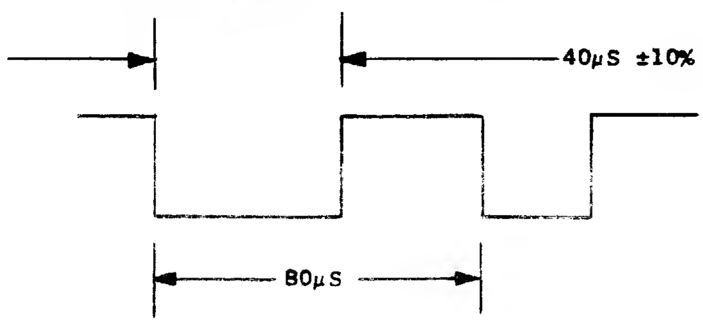
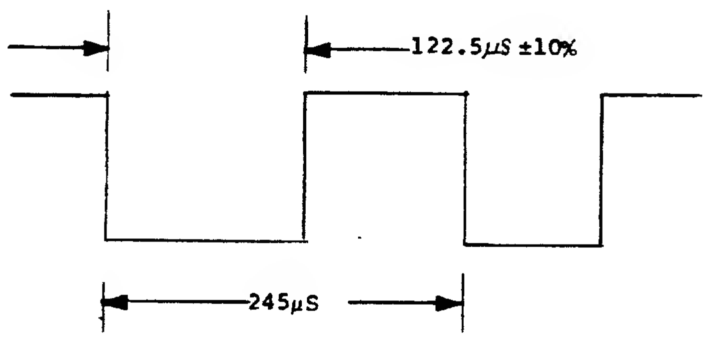
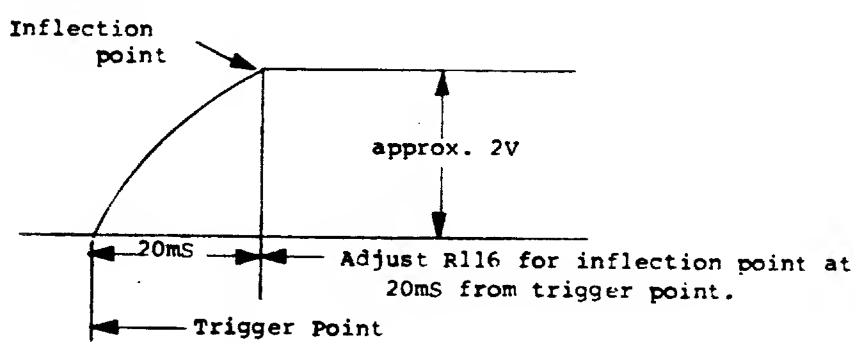


Table 6-4. Performance Tests (Continued)

Step	Procedure / Indication / Corrective action
	Adjust R100 on servo/data board for proper waveform. Perform troubleshooting procedure of table 7-3.
g.	Replace belt and insert data cartridge.
	Tape rewinds at high speed (90 ips) to BOT and then advances at low speed (30 ips) to LP.
h.	Monitor TP8 of servo/data board with oscilloscope.
i.	Apply forward slow signals per table 6-3, column 3.
	Tape runs in forward direction at slow speed (30 ips). The following waveform is observed.



Step	Procedure / Indication / Corrective action
	Adjust R113 on servo/data board for proper waveform. Perform troubleshooting procedure of table 7-3.
j.	Apply select stop signal per table 6-3, column 1.
k.	Monitor TP9 of servo/data board with oscilloscope and trigger on TP1 (positive trigger).
l.	Apply, alternately, forward-reverse signals per table 6-3, column 2.
	Observe the following waveform.



Step	Procedure / Indication / Corrective action
	Adjust R116 on servo/data board for proper waveform. Perform troubleshooting procedure of table 7-3.
m.	Monitor TP9 on servo/data board with oscilloscope while triggering on TP1 (negative trigger).

Table 6-4. Performance Tests (Continued)

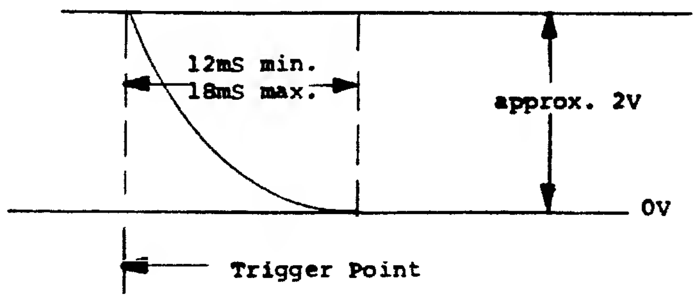
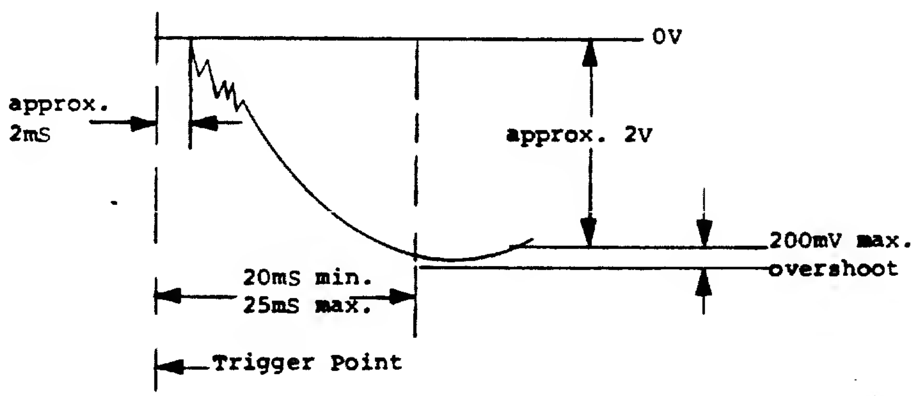
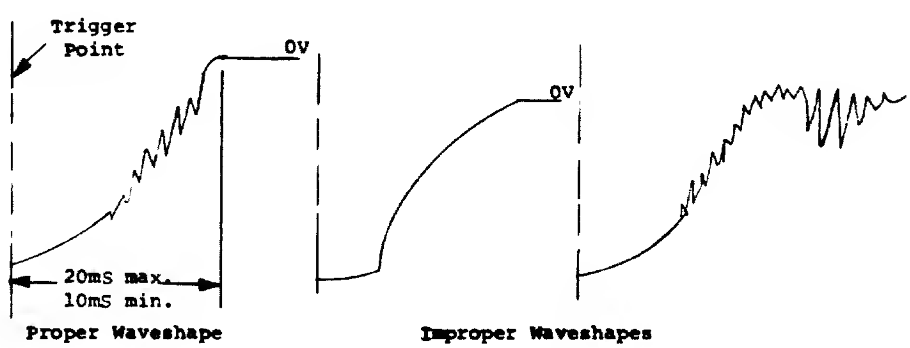
Step	Procedure	Indication	Corrective action
		Observe the following waveform. 	
n.	Monitor TP7 on servo/data board while triggering on TP1 (positive trigger).	Observe the following waveform. 	
o.	Continue to monitor TP7 and trigger on TP1 (negative trigger).	Observe the following waveform. 	Adjust R7 on servo/data board for proper waveform. Perform troubleshooting procedure of table 7-3.

Table 6-4. Performance Tests (Continued)

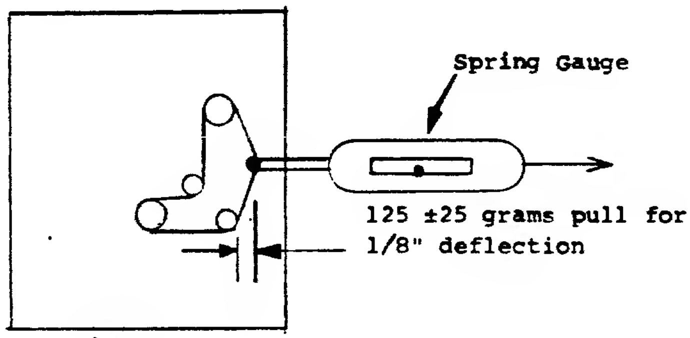
Step	Procedure / Indication / Corrective action
p.	Apply select stop signal per table 6-3, column 1. Measure belt tension using a spring gauge. Apply gauge midway between servo motor and idler pulley as shown below.
	
	Top view of drive
	Indication: Gauge indicates between 100 and 150 grams for a deflection of 1/8 inch.
	Corrective action: Adjust belt tension by loosening the five screws holding the heat sink casting to the chassis. Slide heat sink right or left to increase or decrease belt tension. Adjust heat sink until spring gauge (refer to illustration above) indicates a pull of 125±25 grams for a belt deflection of 1/8 inch. Use scale with 1/8 inch graduations to measure deflection. Tighten screws.
q.	Connect digital counter to TP8 on servo/data board. Use negative trigger.
	Apply forward slow signal per table 6-3, column 3.
	Indication: Digital counter reads 4.1 kHz ±1%.
	Corrective action: Adjust R113 on servo/data board for proper reading. Perform troubleshooting procedure of table 7-3.
r.	Apply fast forward signal per table 6-3, column 4.
	Indication: Digital counter reads 12.3 kHz ±5%.
	Corrective action: Adjust R100 on servo/data board for proper reading. Perform troubleshooting procedure of table 7-3.
s.	Apply stop signal per table 6-3, column 1.
5	SERVO STOP CHECK
a.	Rewind per table 6-3, column 6.
b.	Write a continuous record of all 1s on a blank data cartridge per table 6-3, column 5, for a number of seconds.
c.	Rewind per table 6-3, column 6.

Table 6-4. Performance Tests (Continued)

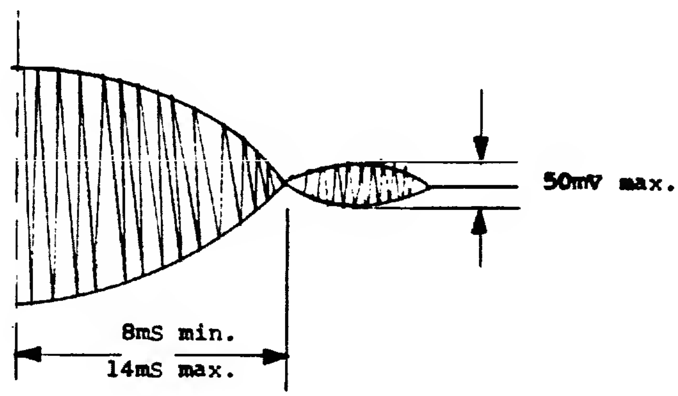
Step	Procedure / Indication / Corrective action
d.	Read a short record alternately in the forward and then reverse direction per table 6-3, column 2. Be sure to stay in the recorded area for the duration of the start, run, and stop distance.
e.	Monitor TP5 on servo/data board with oscilloscope.
	Observe the following waveform (overshoot should not exceed 50 mV pp).
	
	Adjust R7 on servo/data board for proper waveform. Perform troubleshooting procedure of table 7-3.
6	CONTROL CHECK
a.	Read a short record alternately in the forward and reverse direction. Apply forward-reverse signals per table 6-3, column 2.
b.	Monitor TP3 on servo/data board with oscilloscope.
	Observe a 30 mS pulse.
	Adjust R17 on servo/data board for proper pulse. Perform troubleshooting procedure of table 7-4.
c.	Run tape to EOT at high speed by applying fast forward signals per table 6-3, column 4.
	Drive stops at EOT.
	Perform troubleshooting procedure of table 7-4.
	NOTE Unload signal must be true for more than 4 μS.
d.	Apply Unload signal per table 6-3, column 10.
	Drive rewinds tape to BOT and ejects cartridge.
	NOTE Some drives have no automatic eject and consequently will not eject cartridge at BOT.
	Perform troubleshooting procedure of table 7-4.

Table 6-4. Performance Tests (Continued)

Step	Procedure / Indication / Corrective action
7	READ/WRITE CHECK
a.	Insert cartridge into tape drive (cartridge should not be safe).
b.	Write a continuous record of all ones on track 1 per table 6-3, column 5.
c.	Monitor TP5 on servo/data board with oscilloscope. Observe an 8 to 12 V pp sine wave for each track. Adjust R48 on servo/data board for proper sine wave amplitude. Perform troubleshooting procedure of table 7-5.
d.	Repeat steps b and c for tracks 2, 3, and 4 per table 6-3, columns 7, 8, and 9, respectively. Observe an 8 to 12 V pp sine wave for each track.
e.	Repeat step b and monitor U42-13 on servo/data board with oscilloscope. Width of positive-going pulse is 4.7 to 5.3 µS. Perform troubleshooting procedure of table 7-5.
f.	Repeat step d and monitor U19-10 on servo/data board with oscilloscope. Observe square wave at data rate (48,000 bps). Perform troubleshooting procedure of table 7-5.
g.	Stop drive per table 6-3, column 1.
8	MOTOR CHECK
a.	Eject cartridge.
b.	Turn power off.
c.	Carefully slip belt off capstan pulley and remove.
d.	Turn power on.
e.	Connect voltmeter across motor.
f.	Press and hold CIP (fig. 7-1) switch. Voltage does not exceed 7 V. Replace motor.
g.	Turn power off.
h.	Replace belt.

6.6 PERFORM TEST AND CALIBRATION OF MINOR ASSEMBLIES

The following paragraphs provide electrical and mechanical alignment procedures for the tape drive's intimate electronics.

6.6.1 CIP and Safe Switches Alignment

This paragraph provides calibration procedures for the CIP and Safe switches. The procedure should be performed when the performance test parameters (step 2, table 6-3) cannot be met. Adjust the switches as follows:

a. Loosen the two screws holding the CIP and Safe switches to their mounting bracket (fig. 7-1).

b. Insert data cartridge.

c. Move switches forward or backward until they are activated (engaged), but their

cases are not touching the data cartridge. Tighten screws.

6.6.2 Deskewing Head Alignment

Disconnect the Write head from the servo/data board and insert an alignment cartridge using 30 ips speed. Align the head as follows:

a. Attach scope probe to TP5 of the servo/data board. Synchronize to allow a continuous scope display.

b. Loosen both the slotted head screws and the socket head cap screw on the head alignment plate by at least two turns. Do not exert any force on the head alignment plate.

c. With the tape running at 30 ips, with a screwdriver, tighten the head alignment plate using the slotted screws. This will cause the plate to deform slightly toward the deck. If the amplitude of the Read head decreases, continue tightening the screws until the output reaches a minimum, then loosen the screw 1/4 of a turn. This will set the perpendicularity of the head with respect to the surface of the drive plate. When the gap in the head is perpendicular to the track on the alignment tape, the output will be a minimum. It should be noted that it is possible to continue tightening the screw and to find a second minimum of greater amplitude than the first. This represents a false setting and should not be used. If the minimum cannot be obtained with the slotted screws, they should be loosened and the cap screw tightened. This has the effect of moving the head alignment plate away from the deck. This screw should be tightened until a minimum is detected. The screw should then be backed off by 1/4 of a turn.

d. Gently tighten the remaining screws.

e. Remove the alignment cartridge and verify, by looking at the head from the front of the drive, that it appears perpendicular to the chassis. This optically verifies that the alignment has not been made on one of the secondary alignment points.

f. Reinsert the alignment tape and run the drive at 30 ips. Work the screws against each other for the minimum amplitude at TP5.

NOTE

It is important to note that the two cap screws should be worked simultaneously so as not to impart a tilt to the head.

g. Be sure all screws are tight.

6.6.3 Optional Control Board Alignment

For control boards with data tracker circuits it may be necessary to adjust the VCO feedback loop. To do this it is necessary to provide continuous short records to be written and read. (File marks will suffice). Proceed as follows:

a. Trigger on phase-encoded read data TP5 and monitor TP8 (fig. 9-7, sh. 2).

b. Adjust R28 on control board until a smooth waveform is obtained with proper amplitude as shown in figure 7-3.

6.6.4 Solid State TMS Alignment

Align solid state TMS as follows:

a. Adjust TMS Block so that approximately 1/16 inch space exists between front of cartridge and front of TMS block.

b. Monitor R8 (TP1) with oscilloscope probe (fig. 9-2). Cause drive to perform continuous rewind functions. Observe scope track for a train of pulses which will occur at BOT holes and LP hole. When the LP hole is sensed, the TMS must provide a minimum of 1 V pulses for reliable operation. The amplitude of the pulses is affected by varying the 1/16 inch space. See figure 6-1.

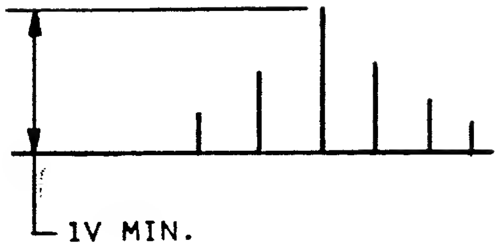


Figure 6-1. TMS Alignment Waveform

6.6.5 Optical Tachometer Alignment

Align the optical tachometer as follows:

a. Loosen the two screws on the optical tach mounting bracket and push tach assembly as far in toward the disk as it will go without touching the disk. Tighten screws.

b. Loosen the two hex screws on the tach disk hub and adjust height of disk as shown in figure 6-2.

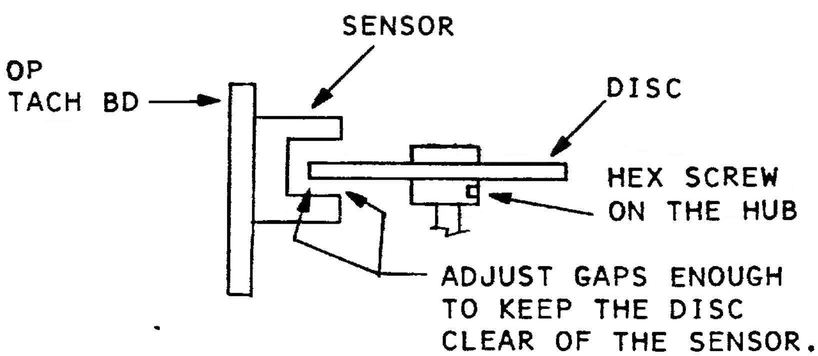


Figure 6-2. Optical Tachometer Alignment

6.7 PACKING TAPES

Tapes should be cycled (wind and rewind) periodically. This packs the tape, to keep the tape tension evenly adjusted and to prevent irregular stacking. This is especially important if only a portion of the tape is used repeatedly or the tape has been dropped or has undergone a significant temperature change.

SECTION 7

TROUBLESHOOTING

7.1 GENERAL

This section contains procedures for locating malfunctions of the tape drive.

7.2 TROUBLESHOOTING

Tables 7-1 through 7-7 provide troubleshooting procedures for the various functional entities of the tape drive. When a malfunction cannot be isolated using the procedures, refer to figures 7-2 through 7-4 and the appropriate schematic diagrams to isolate the malfunction. Refer to the parts list (Section 8) when replacing defective components. The troubleshooting procedures and the corresponding table references are listed below:

Procedure	Table
Power supply	7-1
Indicators	·7-2
Servo/data	7-3
Control circuits	7-4
Read/Write circuits	7-5
TMS	7-6
Optical tachometer	7-7

NOTE 1

Always verify power supply voltages before proceeding to troubleshoot the tape drive.

NOTE 2

If, during a test, tape is run in the forward direction until EOT is reached, rewind it to Load Point and continue test. (An unload command will normally eject the cartridge when tape has been rewound to BOT. Reinsert cartridge. Tape will be advanced to Load Point.)

WARNING

The tape drive contains voltages of sufficient magnitude to result in bodily injury.

7.3 READY LIGHT OFF

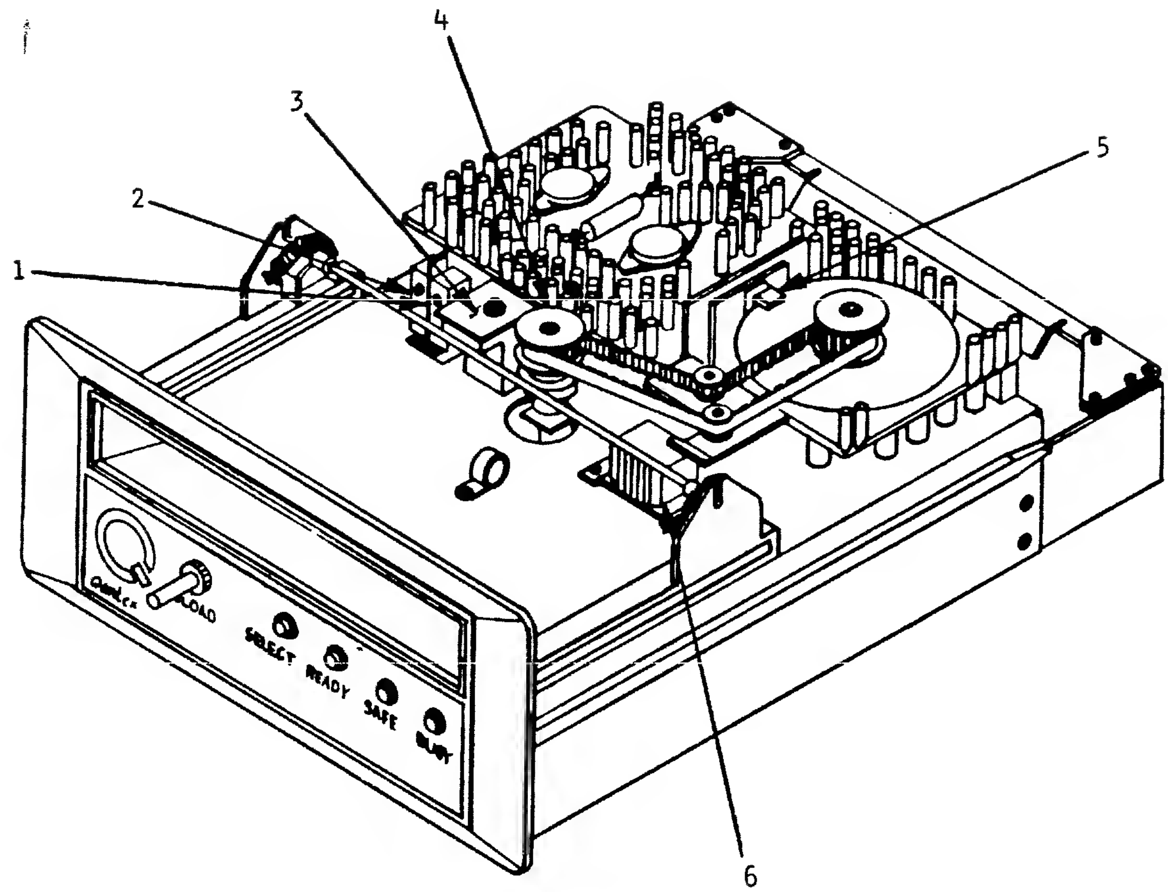
The Ready indicator does not light if either the tachometer LED or the TMS LED is off. Figure 7-1, item 3 identifies the TMS assembly and item 5 identifies the optical tachometer assembly. Refer to table 7-2 when READY indicator is off.

NOTE 1

The TMS (fig. 7-1) does not show any visable illumination because it is emitting in the infra-red spectrum.

NOTE 2

The optical tach lamp is a solid state emitter detector pair. The circuitry checks that the LED emitter is operating. There is no visable illumination since it is operating in the infrared region.



1 - Safe switch
2 - CIP switch
3 - TMS assembly

4 - Drive capstan
5 - Optical tach assembly
6 - Read/Write head and deskew plate

Figure 7-1. Model 650 w/Solid State TMS Operator Maintenance

Table 7-1. Troubleshooting Power Supply

Item	Symptom	Probable cause
1	+18 Vdc incorrect	External supply
2	+12 Vdc missing, incorrect, or unregulated	a. +18 Vdc b. Q1 (fig. 9-5, sh. 2) c. CR4 (fig. 9-5, sh. 2)
3	+5 Vdc missing, incorrect, or unregulated	External supply
4	-5.2 ±0.2 Vdc missing, incorrect, or unregulated	a. -12 Vdc b. CR2 (fig. 9-5, sh. 2)
5	-6.8 ±0.2 Vdc missing, incorrect, or unregulated	a. -12 Vdc b. CR3 (fig. 9-5, sh. 2)
6	-12 Vdc missing, incorrect, or unregulated	a. -18 Vdc b. Q2 (fig. 9-5, sh. 2) c. CR5 (fig. 9-5, sh. 2)
7	-18 Vdc incorrect	External supply

Table 7-2. Troubleshooting Indicators

Item	Symptom	Probable cause
1	SAFE indicator off	a. Safe mechanism on data cartridge b. Lamp DS3 (fig. 9-8) c. Safe switch alignment d. Safe switch (fig. 9-2) e. U9 (fig. 9-5, sh. 1)
2	SELECT indicator off	a. Lamp DS1 (fig. 9-8) b. Incorrect address c. Incorrect setting of address switch U13 (fig. 9-6) d. U13, U12, U14, or U23
3	READY indicator off	a. Lamp DS2 (fig. 9-8) b. Optical tachometer LED (table 7-8) (fig. 9-4) c. Tape mark sensor LED (table 7-7) LED ON or NO TAPE (fig. 9-3) d. CIP switch (fig. 9-2) e. U9-6, U40-6 and U2-6 (fig. 9-5, sh. 1)
4	BUSY indicator off	a. Lamp DS4 (fig. 9-8) b. U9-8 (fig. 9-6, sh. 2) c. U2-12, U9-4 (fig. 9-5, sh. 1)

Table 7-3. Troubleshooting Servo

Item	Symptom	Probable cause
1	Tape drive does not run in reverse at 90 ips when CIP switch is pressed.	a. Ready circuits (table 7-2, step 3) b. Check that servo inputs (fig. 9-5, sh. 3) are: (1) CLKEN (U26-11): High (2) SLOW (U31-3): Low (3) CLKENX (U8-10): Low (4) FWD (U15-11): Low (5) FWDX (U15-9): High c. If above inputs are correct, troubleshoot: (1) Servo amp (fig. 9-5, sh. 3) (2) Power amp (fig. 9-2) (3) Servo motor (fig. 9-2) d. If above inputs in b are incorrect, check control circuits (fig. 9-6).
2	Speed too high	a. TP8 (fig. 9-5, sh. 3) b. Optical tach (fig. 9-4) c. U9, U31, U26 (fig. 9-5, sh. 3)
3	Speed too low	a. TP8 b. U9, U31, or U26 (fig. 9-5, sh. 3)
4	Servo does not respond to test control signals at J9 on control board.	a. Control signals at J9 (fig. 9-6) (see table 6-3 for pins) b. READY and SELECT indicators lit. If not see table 7-2. c. Refer to symptom in step 1, above.
5	Waveform at TP8 cannot be adjusted to 80 μS at 30 ips or 245 μS at 90 ips.	a. Remove dust from slot U1 (fig. 9-4) b. U1 c. Replace optical tach board.
6	Cannot adjust for both 20 mS rise to inflection point and approximately +2 V amplitude.	Circuit failure or change in component value CR12, Q10, CR13, U15-4, U25-1, CR14, U24-7 (fig. 9-5, sh. 3)
7	Waveshape at TP7 (fig. 6-3, sh. 3) has excessive start time and cannot be adjusted lower.	a. Faulty data cartridge (high friction) b. Check for excessive friction in capstan drive wheel assembly and idler pulleys c. Check motor (table 6-4, step 8)
8	Incorrect stop waveform at TP5 (table 6-4, step 5e).	a. U3-8, Q18, R7, or U5 (fig. 9-5, sh. 1)

Table 7-4. Troubleshooting Control Circuits

Item	Symptom	Probable cause
1	Incorrect slow speed STSPX waveform at TP3 (fig. 9-5, sh. 1).	U7-5, R17, C4 (fig. 9-5, sh. 1)
2	Incorrect high speed STSPX waveform at TP3 (fig. 9-5, sh. 1).	U42-5, R206, C107 (fig. 9-5, sh. 1)
3	Drive does not stop when EOT holes are detected.	a. Tape mark sensor (table 7-6) b. U6-11, U6-6, U6-8, or U7-13 (fig. 9-5, sh. 1) c. U3-2, U20-10, U2-11, U19-8, U3-12, U5-7, U3-4, U9-3 (fig. 9-6)
4	Drive does not stop when BOT holes are detected.	a. EOT (symptom of step 3) b. U3-6, U20-14, U19-12, U14-12, U11-15, U9-6 (fig. 9-6)
5	Cartridge not ejected*	a. U4-13, Q19, Q14, or CR19 (fig. 9-5, sh. 4) b. Solenoid (fig. 9-2)

*Some drives do not have automatic eject.

Table 7-5. Troubleshooting Read/Write Circuits

Item	Symptom	Probable cause
1	Unable to adjust range of signals at TP5 to within 8-12 V peak-to-peak (fig. 9-5, sh. 2)	a. Dirt and oxide on head (clean). b. Worn tape c. Tape speed d. Head wear and alignment (para. 6-4) e. Place data cartridge on drive which has data correctly recorded on all tracks. Check waveforms at TP5. (1) If good, check write circuits (item 2). (2) If still incorrect, check read circuits (item 3).
2	Write circuit(s) inoperative	Write circuits (fig. 9-5, sh. 4)
3	Read circuits inoperative	Read circuits (fig. 9-5, sh. 2)
4	Waveform at U42-13 not 3.7 to 4.3 μS	R201, C111, or U42-13, (fig. 9-5, sh. 2)

Table 7-6. Troubleshooting TMS Assembly

Item	Symptom	Probable cause
	NOTE Often problems on TMS assembly are due to broken resistors as a result of careless trouble-shooting.	
1	No servo motion when CIP switch is pressed and BULB ON 2 is low.	a. DS1, DS2, or Q2 on LED driver board b. Q1 on LED board
2	TMS does not detect BOT, and tape runs off.	a. Q1 or Q2 on sensor board b. TMS not properly aligned (refer to para. 6.6.4). c. U1 on sensor board
3	TMS does not detect LP	a. TMS not properly aligned (refer to para. 6.6.4). b. DS1 on LED board c. Q1 on sensor board

Table 7-7. Troubleshooting Optical Tachometer

Item	Symptom	Probable cause
1	No servo motion when CIP switch is pressed and BULB ON 1 is low.	U1 on optical tachometer
2	Run-away high-speed servo	a. U1 on optical tachometer b. U2 on optical tachometer c. Optical tachometer disc not properly aligned (para. 6.5.5), or disc is dirty.

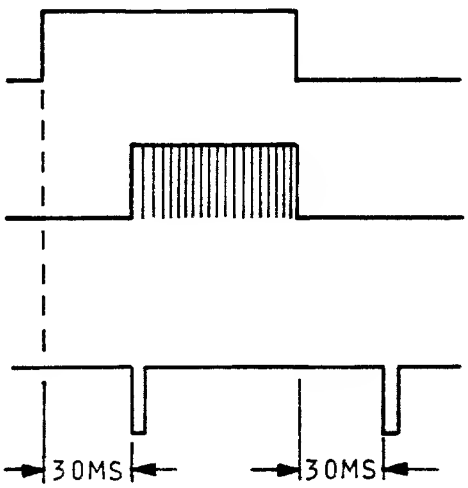
TEST POINT	WAVEFORM	CONDITIONS
TP1 (TR) TP2 (READ DATA) TP3 (NESPX)		<u>TP1, 2, AND 3</u> 1. SYNC: (+) EDGE OF TR 2. TIME BASE: DEPENDS ON DURATION OF TR 3. VERTICAL DEFLECTION: 1V/CM
TP4 (PEW/ PEOT CLR)	 ΔT IS THE DELAY FROM OCCURENCE OF SEW AND OR SEOT.	<u>TP4</u> NOTE PEW/PEOT CLR OCCURS COINCIDENTALLY WITH TMSB. TMSB OCCURS WHENEVER THE TAPE REACHES EW, EOT, OR BOT AND IS SLIGHTLY DELAYED.

Figure 7-2. Control Board, Voltage and Waveform Data

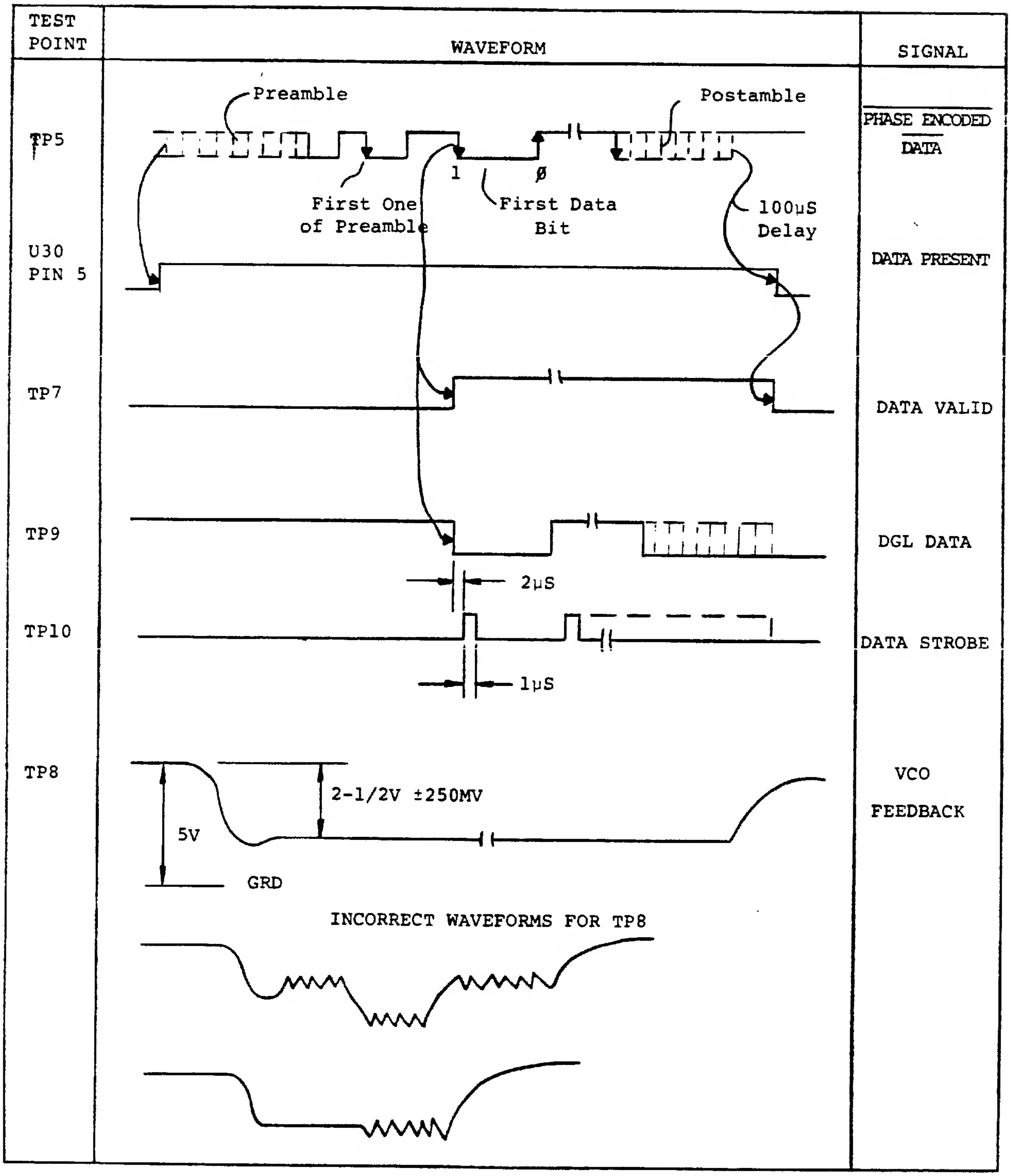


Figure 7-3. Control Board w/Data Tracker Circuit, Voltage and Waveform Data

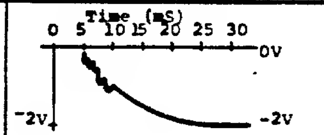
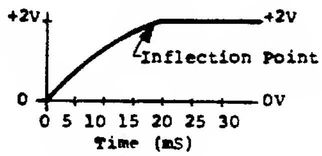
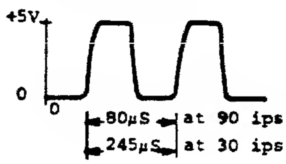
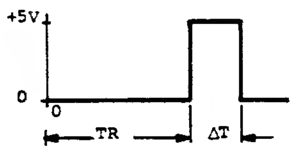
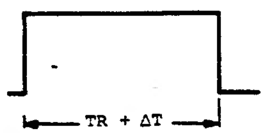
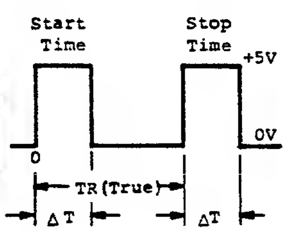
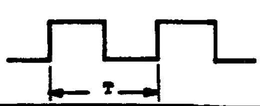
Test Point	Waveform	Conditions
TP7		1. Oscilloscope triggered on (+) edge of TR. 2. Time Base: 5mS/cm 3. Vertical Deflection: 1V/cm 4. TR: 10Hz (max) square wave
TP9		1. Same as TP7 2. Inflection point adjusted for 20mS.
TP8		1. Waveform adjusted to be symmetrical. 2. Time Base: 20µS/cm 3. Vertical Deflection: 1V/cm 4. Sync: Internal (- or +)
TP1		TP 7 and 9 1. Time Base: Depends on duration of TR true. 2. Vertical Deflection: 1V/cm 3. Sync: (+) edge of TR Note: ΔT = 8 to 14mS at 30 ips ΔT = 24 to 46mS at 90 ips
TP2		
TP3		1. Sync: (+) edge of TR 2. Time Base: Depends on duration of TR true. 3. Vertical Deflection: 1V/cm Note: ΔT = 30mS at 30 ips ΔT = 75mS (approx.) at 90 ips
TP5		1. Time Base: 10µS/cm 2. Vertical Deflection: 5V/cm 3. Sync: Internal Note: a. T = 20µS when readings are all 1's or 0's. b. T = 40µS when reading alternate 1's and 0's.
TP6		

Table 7-4. Servo/Data Board, Voltage and Waveform Data

SECTION 8

PARTS LIST

This section contains a vendor code list, parts lists, and parts locator diagrams for all units of the tape drive.

List of Manufacturers

MFR CODE	MANUFACTURERS' NAME	ADDRESS
00779	AMP, Inc.	Harrisburg, PA
01121	Allen-Bradley Co.	Milwaukee, WI
01295	Texas Instruments	Dallas, TX
01963	Cherry Electrical Products	Highland Park, IL
04713	Motorola Semiconductor	Phoenix, AZ
06751	Semcor Components, Inc.	Phoenix, AZ
07263	Fairchild Semiconductor	Mountain View, CA
07342	North Atlantic Industries, Inc.	Hauppauge, NY
11869	Sangamo-Weston	Weymouth, MA
12040	National Semiconductor	Danbury, CT
15818	Teledyne Inc., Amelco Semiconductor	Mountain View, CA
16299	Corning Glass Works	Raleigh, NC
18565	Chomerics, Inc.	Woburn, MA
22526	Berg Electronics, Inc.	New Cumberland, PA
23223	CTS Microelectronics	Lafayette, IN
31918	International Electro Exchange, Inc.	Minneapolis, MN
32098	Pittman Products, Inc.	Huntington Park, CA
44655	Ohmite Manufacturing	Skokie, IL
50625	Revere Corp. of America	Wallingford, CT
56289	Sprague Electric Co.	North Adams, MA
71279	Cambridge Thermonic Corp.	Cambridge, MA
71590	Centralab	Milwaukee, WI
72619	Dialight Corp.	Brooklyn, NY
72982	Erie Technological Labs	Erie, PA
73138	Beckman Instruments, Inc.	Fullerton, CA
73949	Guardian Electric	Chicago, IL
76527	Moffatt Bearings	Philadelphia, PA
80545	Hunter Spring	Hatfield, PA
83086	New Hampshire Ball Bearings	Peterborough, NH
84171	Arco Electronics, Inc.	Great Neck, NY
84411	Goodall, TRW Capacitor Div.	Ogallala, NE
84830	Lee Spring Co., Inc.	Brooklyn, NY
91833	Keystone Electronics Corp.	New York, NY
91886	Malco Mfg. Co.	Chicago, IL
95263	Leecraft Mfg. Co., Inc.	Long Island City, NY
nfsc	York Industries, Inc.	303 Nassau Blvd. Garden City, New York
unrest.	Unrestricted (any qualified manufacturer)	

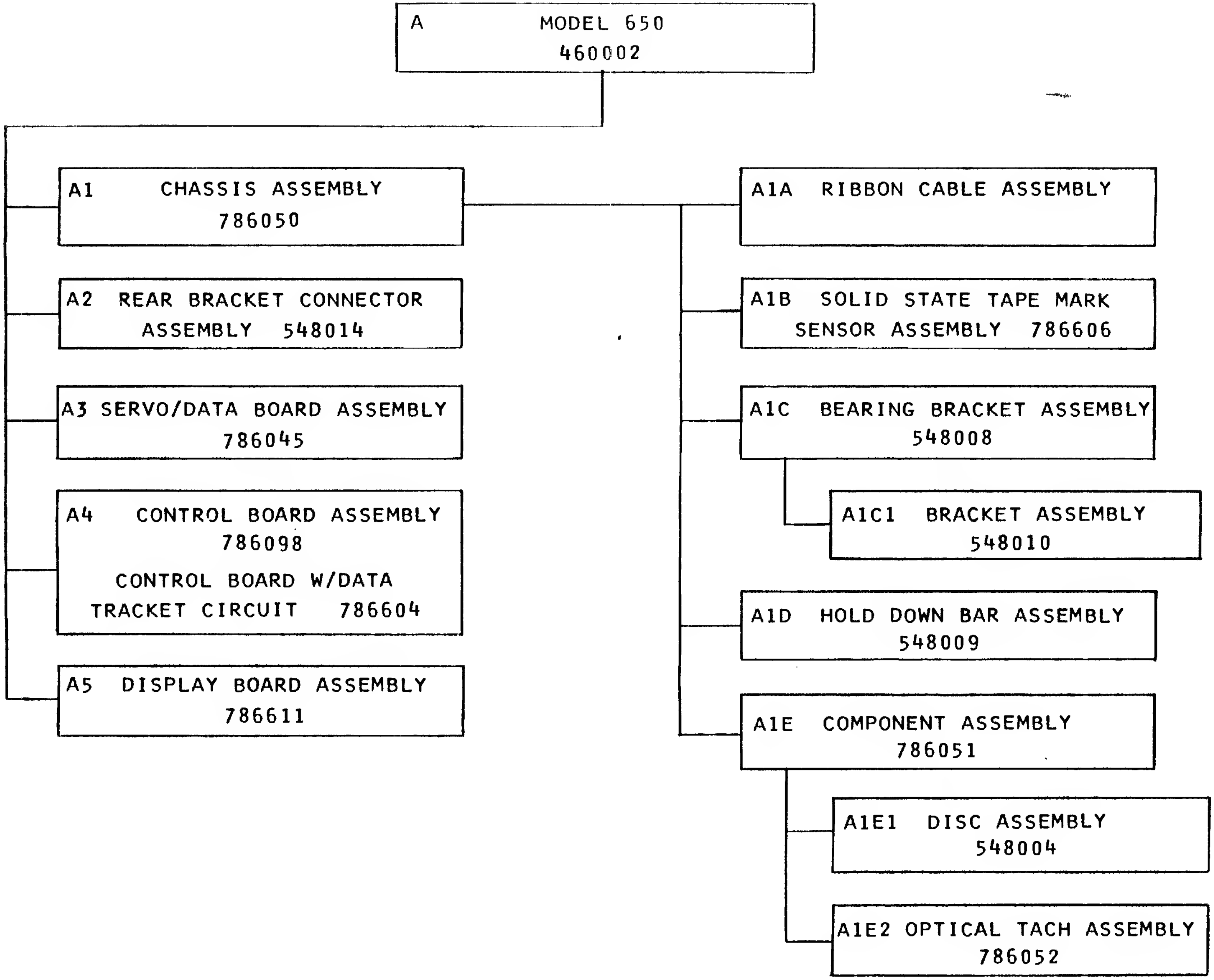


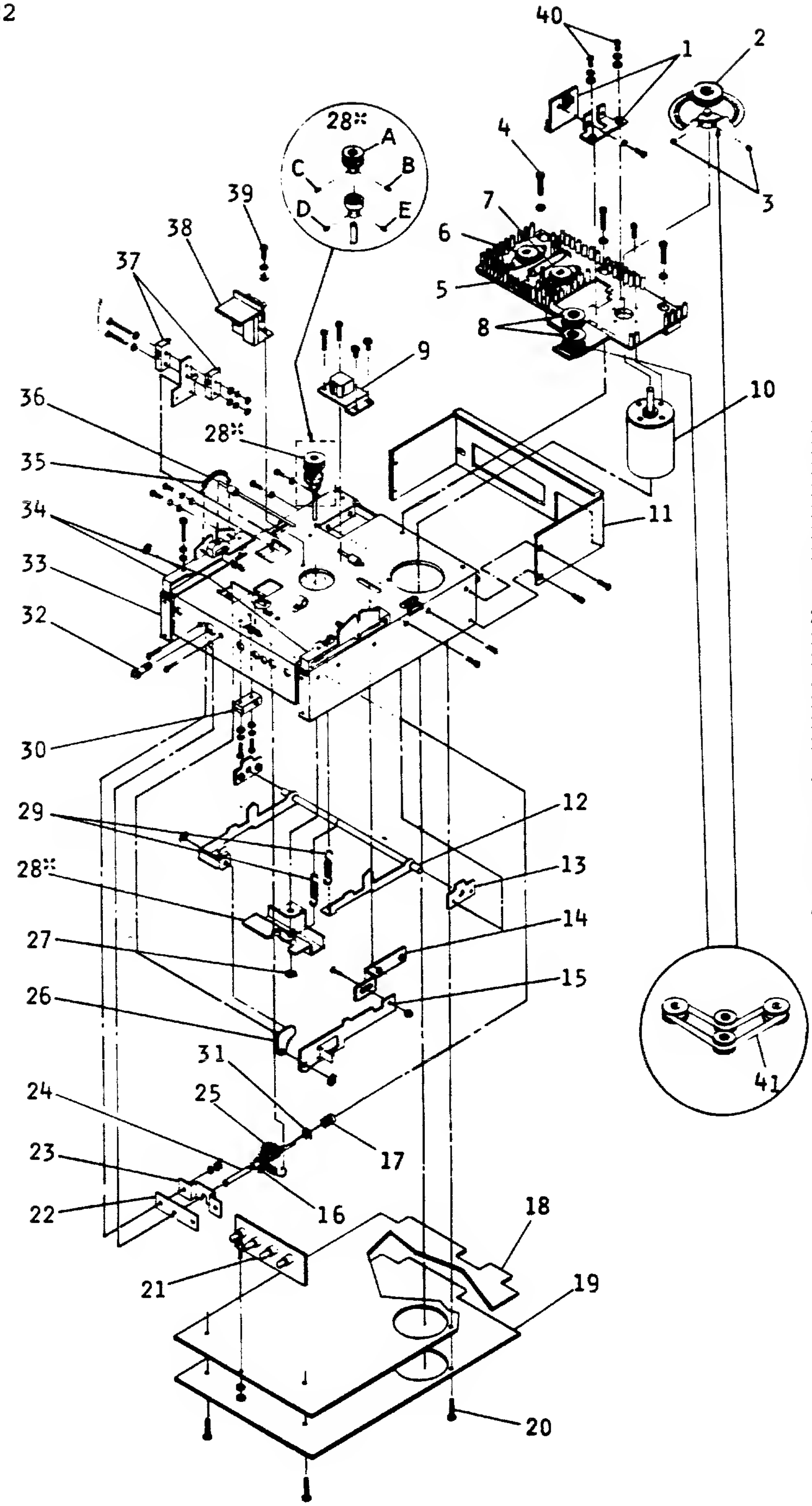
Figure 8-1. Tape Drive, Family Tree of Replaceable Assemblies

Replacement Parts List: Model 650 Tape Drive

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
A	Model 650, Magnetic Tape Transport	460002			1
A1	Chassis Assembly	786050			1
	Latch - Weldment	296034			1
	Sleeve Bearing	880118			3
	Spring, Manual Eject	296045			1
	Drive Belt	880014	nsfc	40DP143M1/8	1
	Spring, Ext.	880010	84830	LE026C00SS	1
	Spring, Ext.	880011	84830	LE026C2SS	2
	Spring, Ext.	880012	84830	LE029C00SS	1
	Spring, Compression	880013	84830	LC032E1SS	1
	Spring, Tape Eject	880156	80545	SH5E15	1
	Switch	880121	01963	E61-00A	3
	Solenoid	880027	73949	11I24VDC (Special)	1
A1A	Ribbon Cable Assembly	548000			1
	Cable, Ribbon	980002			AR
	Connector Housing	880516	22526	65039-30	2
	Contact	880204	22526	47714	14
A1B	Solid State Tape Mark Sensor	786606 (786648)			1
A1C	Bearing Bracket Assembly	548008			1
A1C1	Bracket Assembly	548010			1
	Ball Bearing	880003	83086	SFR1563PPEE(K25)	2
	Drive Wheel	296002			1
A1D	Hold-Down Bar Assembly	548009			1
	Bearing, Sleeve, Oil Impreg., Bronze	880119	76527	B25-2	2
A1E	Component Bracket Assembly	786051			1
	Ball Bearing	880003	83086	SFR1563PPEE(K25)	4

Replacement Parts List: Model 650 Tape Drive (Continued)

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
A1E1	Disc Assembly	548004			1
B1	Motor, Hi-Temp Winding	880023	32098	9113-12VDC	1
A1R1	Resistor, Wirewound, 1Ω, 5W	880104	56289	452E1R05	1
Q1	Transistor, Power	880047	04713	MJ900	1
Q2	Transistor, Power	880048	04713	MJ1000	1
	Greasless Insulator	882808	18565	60-11-4305-1664	2
A1E2	Optical Tach Assembly (Table 7-4) (Same as 786268)	786052			1
	Connector Housing, Mini-Latch	880516	22526	65039-031	1
	Contact, Crimp, Mini-PV	880204	22526	47714	6
A2	Rear Connector Bracket Assembly	548014			1
A3	Servo/Data Board Assembly	786045			1
A4	Control Board Assembly	786098			1
A4	Control Board Assembly, w/Data Tracker Circuit	786604			1
A5	LED Display Board Assembly	786611			1
A6	Tape Head Assembly				1
	Magnetic Head per Option				
	<u>Option</u> <u>Description</u>				
	4T/DGE 4 track with Erase	880148			
	4T/DGH 4 track	880147			



LEGEND

1 - OPTICAL TACH
2 - DISC ASSEMBLY
5 - COMPONENT BRACKET
6 - POWER TRANSISTOR
7 - POWER TRANSISTOR
8 - PULLEYS
9 - TAPE HEAD ASSEMBLY
10 - MOTOR SHAFT
11 - REAR CONNECTOR BRACKET
12 - WELDMENT
14 - SUPPORT, ARM
15 - ARM, SOLENOID
16 - GRIP RING
17 - SPRING, COMPRESSION
18 - SERVO/DATA
19 - CONTROL BOARD
21 - LED DISPLAY BOARD
22 - FILLER PLATE
23 - SHAFT RETAINING BRACKET
24 - SHAFT, MANUAL EJECT
25 - SPRING, MANUAL EJECT
26 - LINK, PIVOT
28 - BEARING BRACKET ASSEMBLY
29 - SPRING, EXTENDER
30 - SWITCH CABLE ASSEMBLY
31 - "E"RING
34 - GUIDE, LEFT & RIGHT
36 - HOLD DOWN BAR ASSEMBLY
37 - CABLE ASSEMBLY - SWITCHES
38 - TAPE MARK SENSOR
41 - PULLEY TIMING BELT

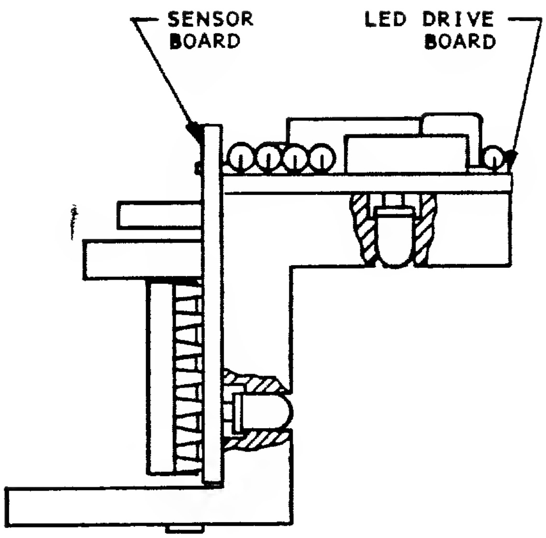
Figure 8-2. Exploded Assembly of Tape Drive

Replacement Parts List - Solid State Tape Mark Sensor - 786606 and 786648

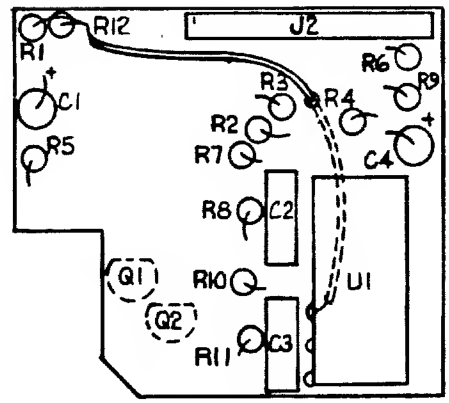
Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
A1B	Solid State Tape Mark Sensor (18V) Solid State Tape Mark Sensor (12V)	786606 786648			
A1BA1	Sensor Board Assembly	548041			1
C1	Capacitor, Elect. Tantalum 1µf, 10V	803409	56289	150D105X9010A2	2
C2	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0-103Z	2
C3	Same as C2				
C4	Same as C1				
Q1	Photo Transistor	880105	01295	TIL78	2
Q2	Same as Q1				
R1	Resistor, Composition 100kΩ, 1/4W, ±5%	880846	01121	CB1045	2
R2	Resistor, Composition 2kΩ, 1/4W, ±5%	880086	01121	CB2025	3
R3	Resistor, Composition 3.9kΩ, 1/4W, ±5%	880782	01121	CB3925	1
R4	Same as R1				
R5	Resistor, Composition 430Ω, 1/4W, ±5%	805194		RCR07G431JP	1
R6	Same as R2				
R7	Resistor, Composition 10kΩ, 1/4W, ±5%	880092	01121	CB1035	2
R8	Resistor, Composition 20kΩ, 1/4W, ±5%	880096	01121	CB2035	2
R9	Same as R2				
R10	Same as R7				
R11	Same as R8				
R12	Resistor, Composition 36kΩ, 1/4W, ±5%	802904	01121	CB3625	1
U1	Integrated Circuit	807626	12040	LM339N	1
A1BA2	LED Drive Board (18V)	548042			1
C1	Capacitor, Tantalum 3.3µf, 35V, ±20%	801311	56289	150D335X0035B2	1
C2	Capacitor, Ceramic .1µf, 50V, ±10%	883884	71590	CW30C104K	1

Replacement Parts List - Solid State Tape Mark Sensor - 786606 and 786648 (Continued)

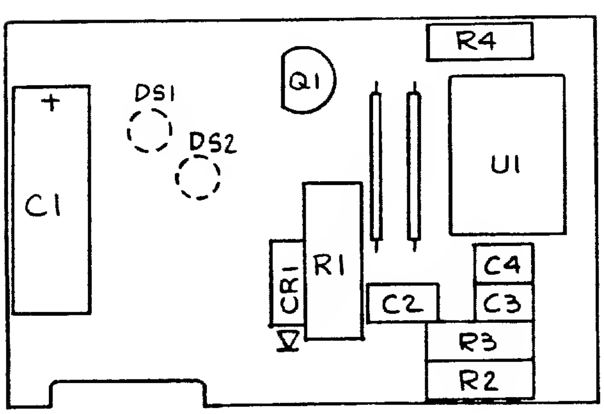
Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C3	Capacitor, Ceramic .01µf, 50V, ±10%	883798	71590	CW15C103KA	2
C4	Same as C3				
CR1	Diode	880052	04713	1N4154	1
CR2	Diode	882460	QPL	JAN 1N753A	2
CR3	Same as CR2				
DS1	LED	883257	07342	883257	1
DS2	LED	883258	07342	883258	1
Q1	Transistor	883299	07263	2N2907	1
R1	Resistor, Composition 220Ω, 1/2W, ±5%	884240	QPL	RCR20G221JP	1
R2	Resistor, Composition 2.7kΩ, 1/4W, ±5%	880746	01121	CB2725	1
R3	Resistor, Composition 5.6kΩ, 1/4W, ±5%	883022	01121	CB5625	1
R4	Resistor, Composition 1kΩ, 1/4W, ±5%	880084	01121	CB1025	1
U1	Integrated Circuit	808411	01295	NE555P	1
A1BA2	LED Drive Board (12V)	548064			1
C1	Capacitor, Tantalum 3.3µf, 35V, ±20%	801311	56289	150D335X0035B2	1
C2	Capacitor, Ceramic .1µf, 50V, ±10%	883884	71590	CW30C104K	1
C3	Capacitor, Ceramic .01µf, 50V, ±10%	883798	71590	CW15C103KA	2
C4	Same as C3				
CR1	Diode	880052	04713	1N4154	1
DS1	LED	883257	07342	883257	1
DS2	LED	883258	07342	883258	;
R1	Resistor, Composition 150Ω, 1/2W, ±5%	801140	01121	EB1515	1
R2	Resistor, Composition 2.7kΩ, 1/4W, ±5%	880746	01121	CB2725	1
R3	Resistor, Composition 5.6kΩ, 1/4W, ±5%	883022	01121	CB5625	1
R4	Resistor, Composition 750Ω, 1/4W, ±5%	803229	01121	CB7515	1
U1	Integrated Circuit	808411	01295	NE555P	1



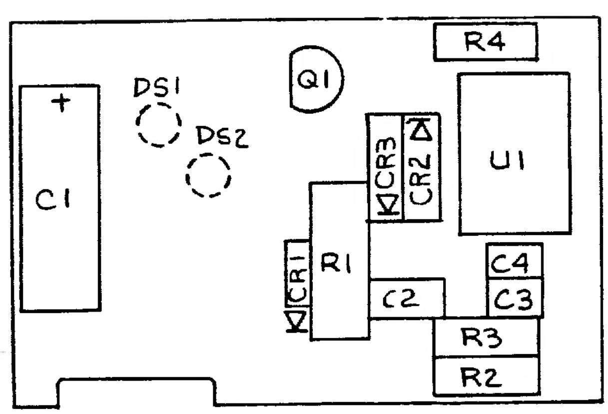
Solid State TMS



Sensor Board



Led Board (12 V)

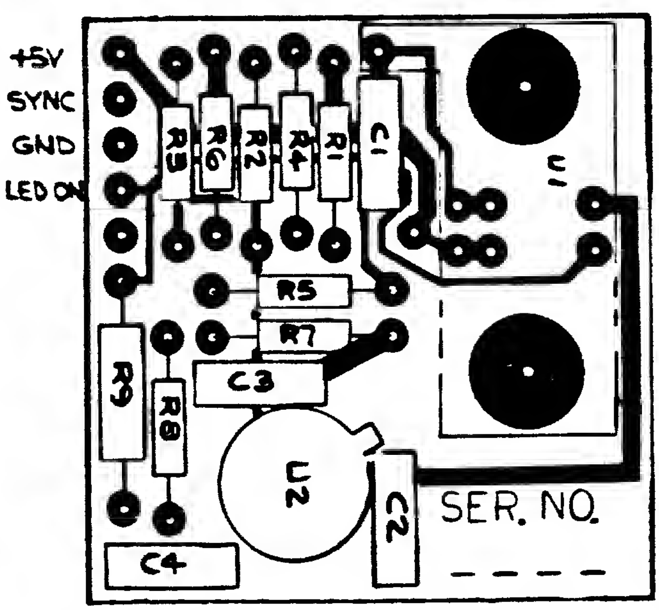


Led Board (18 V)

Figure 8-3. Solid State Tape Mark Sensor, Parts Locator

Replacement Parts List: Optical Tachometer Assembly - 786052

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
A1E2	Optical Tachometer Assembly	786052			
C1	Capacitor, Ceramic, .1µf, 100V, ±10%	880640	QPL-11015	CKR06BX104KP	3
C2	Same as C1				
C3	Same as C1				
C4	Capacitor, Ceramic, .01µf, 200V, ±10%	880834	QPL-11015	CKR06BX103K	1
R1	Resistor, Composition, 1KΩ, 1/8W, ±5%	880694	01121	BB1025	2
R2	Resistor, Composition, 10KΩ, 1/8W, ±5%	880830	01121	BB1035	1
R3	Resistor, Composition, 1MΩ, 1/8W, ±5%	880833	01121	BB1055	1
R4	Resistor, Composition, 4.7KΩ, 1/8W, ±5%	880829	01121	BB4725	1
R5	Resistor, Composition, 33KΩ, 1/8W, ±5%	880831	01121	BB3335	1
R6	Resistor, Composition, 1.8KΩ, 1/8W, ±5%	880827	01121	BB1825	1
R7	Same as R1				
R8	Resistor, Composition, 43KΩ, 1/8W, ±5%	880832	01121	BB4335	1
R9	Resistor, Metal Film, 110Ω, 1/8W, ±1%	880837	16299	C4	1
U1	Switch, Optical	296221	07342	296221	
U2	Integrated Circuit	880836	12040	LM111H	1



NOTE: U1 is located on opposite side of board.

Figure 8-4. Optical Tachometer, Parts Locator

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
A3	Servo/Data Board	786045			
C1	Capacitor, Elect. Tantalum 4.7µf, 10V, ±20%	880072	06751	TS1K10-475	3
C2	Same as C1				
C4	Capacitor, Elect. Tantalum 10µf, 20V, ±20%	880073	06751	TS2K20-106	4
C5	Capacitor, Ceramic .001µf, 1000V, ±10%	880038	72982	801000-X5F0102K	11
C6	Capacitor, Elect. Tantalum 250µf, 6V	880161	56289	TE-1105	2
C7	Same as C5				
C8	Capacitor, Elect. Tantalum 2.2µf, 20V, ±20%	880518	56289	150D225X0020A2	2
C9	Same as C5				
C10	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835000Y5U0103Z	35
C11	Same as C5				
C12	Capacitor, Ceramic .47µf, 50V, ±20%	880817	71590	CY20C474M	3
C13	Same as C10				
C14	Capacitor, Elect. Tantalum 1µf, 12V, ±20%	880070	06751	TS1K10-105	5
C17	Same as C10				
C18	Capacitor, Ceramic 10pf, 100V, ±.5pf	880592	72982	831000C0G0100D	1
C21	Same as C12				
C23	Same as C10				
C26	Capacitor, Ceramic .1µf, 25V, +80-20%	880032	72982	581000Y5U0104Z	5
C28	Same as C10				
C29	Same as C14				
C30	Capacitor, Ceramic 3.3pf, 1000V, ±.5%	880041	71590	DD3R3	1
C31	Capacitor, Ceramic .1µf, 50V, ±20%	808931	91674	8121-050-651-104M	2
C32	Same as C5				
C33	Same as C26				

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C34	Capacitor, Ceramic 470pf, 600V, ±10%	880594	72982	831X5R471K	1
C35	Capacitor, Ceramic 150pf, 1000V, ±10%	880040	71590	DD151	1
C36	Same as C31				
C37	Same as C10				
C38	Same as C10				
C39	Same as C10				
C40	Same as C14				
C41	Same as C10				
C42	Same as C26				
C43	Capacitor, Elect. Tantalum 47µf, 20V, ±20%	880074	06751	TS3K20-476	2
C44	Same as C10				
C47	Same as C26				
C48	Same as C43				
C51	Same as C5				
C52	Same as C8				
C53	Same as C10				
C55	Same as C26				
C56	Capacitor, Ceramic .02µf, 18V, ±20%	880588	72982	5733000X5F0203M	1
C57	Capacitor, Fixed Film .0039µf, 80V, ±10%	880980	56289	192P392R8	1
C60	Same as C10				
C61	Same as C10				
C62	Same as C4				
C63	Same as C1				
C64	Capacitor, Fixed Film .012µf, 80V, ±10%	880979	56289	192P1239R8	1
C66	Capacitor, Fixed Film .15µf, 80V, ±10%	880819	56289	192P1549R8	1
C67	Same as C10				
C68	Capacitor, Fixed Film 220pf, 500V, ±10%	802341	72136	DM15-221K	1

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C69	Capacitor, Ceramic .01µf, 25V, +80-20%	880034	72982	5835-000-Y5U0-103Z	1
C70	Same as C12				
C71	Capacitor, Ceramic .05µf, 50V, +80-20%	880198	84171	TCD-503Z	1
C72	Same as C5				
C73	Same as C5				
C74	Same as C5				
C75	Same as C5				
C76	Same as C10				
C78	Same as C10				
C79	Same as C10				
C80	Same as C4				
C81	Same as C10				
C82	Same as C10				
C83	Same as C10				
C84	Same as C4				
C85	Same as C5				
C87	Same as C6				
C88	Same as C10				
C89	Same as C10				
C90	Same as C10				
C92	Same as C10				
C93	Same as C10				
C94	Same as C10				
C95	Same as C10				
C98	Same as C10				
C99	Same as C10				
C100	Same as C10				
C101	Same as C10				
C103	Same as C14				
C104	Same as C14				
C105	Capacitor, Elect. Tantalum 100µf, 10V, ±20%	880075	06751	TS3K10107	1

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
C107	Capacitor, Elect. Tantalum 27µf, 10V, ±10%	880816	56289	150D276X9010B2	1
C109	Capacitor, Fixed Film .0015µf, 100V, ±10%	880978	84411	663UW152-9-1	3
C110	Same as C109				
C111	Same as C109				
C113	Same as C10				
C114	Same as C10				
C115	Same as C10				
C116	Capacitor, Ceramic .47µf, 50V, ±10%	880772	QPL	CK06BX474KP	1
C118	Capacitor, Ceramic 500pf, 500V, ±10%	883087	72982	831-000X5F0501K	1
CR2	Diode	880196	04713	1N5231A	1
CR3	Diode	880050	04713	1N5235	2
CR4	Diode	880051	04713	1N5242	2
CR5	Same as CR4				
CR6	Diode	880052	04713	1N4154	13
CR7	Diode	880714	04713	1N4735A	1
CR8	Same as CR6				
CR9	Same as CR6				
CR10	Same as CR6				
CR11	Same as CR6				
CR12	Same as CR3				
CR13	Same as CR6				
CR14	Same as CR6				
CR15	Same as CR6				
CR16	Diode	880334	04713	1N5252B	1
CR17	Diode	880713	04713	1N751	2
CR18	Same as CR17				
CR19	Diode	880112	04713	1N4002	1
CR20[1]	Diode	880052	04713	1N4154	1
CR21[1]	Same as CR20				1

[1]Used only on -3 & -4 assemblies.

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
CR22[1]	Same as CR20				1
CR23[1]	Same as CR20				1
CR24	Same as CR6				
CR25	Same as CR6				
CR26[2]	Same as CR20				1
CR27	Same as CR6				
CR28	Same as CR6				
CR30	Same as CR6				
Q1	Transistor	880053	04713	MJE2020	1
Q2	Transistor	880111	04713	MJE2370	1
Q7	Transistor	880604	15818	E176	2
Q8	Transistor	880823	07263	2N4360	3
Q9	Same as Q8				
Q10	Same as Q8				
Q12	Transistor	880106	01295	TIS75	1
Q13	Transistor	880123	unrest.	2N2369A	4
Q14	Transistor	880002	04713	MJE701	1
Q15[2]	Transistor	880823	07263	2N4360	1
Q16[2]	Transistor	880123	07263	2N2369A	1
Q18	Transistor	880124	unrest.	2N2907A	3
Q19	Same as Q13				
Q20	Same as Q18				
Q21	Same as Q13				
Q22	Same as Q13				
Q23	Same as Q18				
Q25	Same as Q7				
R1	Resistor, Composition 4.3kΩ, 1/4W, ±5%	880849	01121	CB4325	1
R3	Resistor, Composition 1kΩ, 1/4W, ±5%	880084	01121	CB1025	22
R4	Same as R3				

[1]Used only on -3 & -4 assemblies.
[2]Used only on -2 & -4 assemblies.

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R5	Resistor, Composition 330Ω, 1/4W, ±5%	880080	01121	CB3315	6
R6	Same as R3				
R7	Potentiometer, 50kΩ	880650	23223	362T503B	1
R10	Resistor, Composition 43kΩ, 1/4W, ±5%	802723	01121	4335	1
R12	Same as R3				
R13	Same as R3				
R17	Potentiometer, 25kΩ	880297	71279	362TPC253A	1
R19	Same as R3				
R21	Same as R3				
R22	Resistor, Composition 4.7kΩ, 1/4W, ±5%	880088	01121	CB4725	11
R23	Same as R5				
R24	Same as R3				
R25	Same as R22				
R26	Resistor, Composition 10kΩ, 1/4W, ±5%	880092	01121	CB1035	11
R27	Same as R5				
R28	Resistor, Composition 20kΩ, 1/4W, ±5%	880096	01121	CB2035	1
R29	Same as R22				
R30	Same as R3				
R31	Same as R3				
R32	Same as R5				
R33	Same as R26				
R37	Same as R3				
R39	Resistor, Composition 12kΩ, 1/4W, ±5%	880093	01121	CB1235	3
R41	Same as R39				
R43	Resistor, Composition 5.1kΩ, 1/4W, ±5%	880089	01121	CB5125	9
R46	Same as R22				
R47	Same as R43				
R48	Potentiometer, 500Ω	880981	23223	362S501B	1

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R49	Resistor, Composition 560Ω, 1/4W, ±5%	880083	01121	CB5615	5
R50	Resistor, Composition 2.7kΩ, 1/4W, ±5%	880746	01121	CB2725	1
R51	Resistor, Composition 180Ω, 1/4W, ±5%	880364	01121	CB1815	1
R52	Resistor, Composition 100Ω, 1/2W, ±5%	880601	01121	EB1015	1
R53	Resistor, Composition 510kΩ, 1/4W, ±5%	880099	01121	CB5145	2
R54	Resistor, Composition 3.9kΩ, 1/4W, ±5%	880782	01121	CB3925	1
R55	Resistor, Composition 1.2kΩ, 1/4W, ±5%	880085	01121	CB1225	1
R56	Same as R43				
R57	Resistor, Composition 3kΩ, 1/4W, ±5%	880784	01121	CB3025	4
R58	Same as R43				
R59	Same as R39				
R60	Same as R22				
R61	Resistor, Composition 6.2kΩ, 1/4W, ±5%	880566	01121	CB6225	2
R63	Same as R22				
R64	Same as R22				
R65	Same as R57				
R66	Same as R53				
R67	Resistor, Composition 150Ω, 1/4W, ±5%	880200	01121	CB1515	1
R68	Same as R57				
R69	Same as R22				
R70	Same as R3				
R72	Same as R57				
R73	Resistor, Composition 220Ω, 1/4W, ±5%	880078	01121	CB2215	2
R74	Same as R22				
R75	Resistor, Composition 6.8kΩ, 1/4W, ±5%	880090	01121	CB6825	1

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R76	Same as R3				
R77	Resistor, Composition 30Ω, 1/2W, ±5%	880102	01121	EB3005	1
R85	Resistor, Metal Film 1kΩ, 1/8W, ±1%	880054	16299	NA55-1K	2
R86	Resistor, Composition 33kΩ, 1/8W, ±2%	806743	16299	NC4-33K	1
R87	Resistor, Metal Film 10kΩ, 1/8W, ±1%	880044	16299	NA55-10K	5
R90	Resistor, Composition 390Ω, 1/4W, ±5%	880081	01121	CB2915	4
R91	Resistor, Metal Film 10kΩ, 1/4W, ±2%	880596	16299	C4	3
R92	Same as R91				
R93	Same as R91				
R94	Same as R85				
R95	Same as R87				
R96	Same as R87				
R97	Resistor, Composition 13kΩ, 1/4W, ±5%	880094	01121	CB1335	2
R98	Resistor, Composition 5.6kΩ, 1/4W, ±5%	883022	01121	CB5625	2
R99	Same as R3				
R100	Potentiometer, 5kΩ, 3/4W, ±10%	880649	73138	79PR5K	2
R101	Same as R26				
R102	Resistor, Composition 510Ω, 1/4W, ±5%	880082	01121	CB5115	3
R103	Same as R43				
R104	Same as R43				
R105	Resistor, Composition 270Ω, 1/4W, ±5%	880079	01121	CB2715	4
R106	Same as R26				
R107	Same as R87				
R108	Same as R87				
R109	Same as R105				
R110	Same as R98				

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R111	Same as R3				
R112	Same as R26				
R113	Same as R100				
R114	Same as R102				
R116	Potentiometer, 5kΩ, 3/4W, ±10%	883066	11869	850W-5K	1
R119	Resistor, Metal Film 56kΩ, 1/4W, ±2%	880600	16299	C4	1
R120	Same as R3				
R122	Same as R26				
R123	Resistor, Composition 2.7MΩ, 1/4W, ±5%	804355	01121	CB2955	1
R125	Same as R3				
R127	Resistor, Metal Film 301kΩ, 1/4W, ±2%	880597	16299	C4	1
R128	Same as R97				
R129	Resistor, Composition 24Ω, 1/4W, ±5%	802397	01121	CB2045	1
R130	Same as R26				
R131	Resistor, Composition 2.4kΩ, 1/4W, ±5%	880087	01121	CB2425	3
R132	Same as R90				
R133	Same as R102				
R134	Resistor, Composition 1MΩ, 1/4W, ±5%	880100	01121	CB1055	1
R135	Same as R131				
R136	Same as R26				
R137	Same as R43				
R138	Same as R90				
R139	Same as R49				
R140	Same as R49				
R141	Same as R49				
R142	Same as R49				
R143	Same as R26				
R144	Same as R22				
R146	Same as R26				

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R148	Same as R131				
R149	Same as R5				
R150	Same as R3				
R151	Resistor, Composition 470Ω, 1/4W, ±5%	880567	01121	CB4715	2
R153	Same as R22				
R156	Resistor, Composition 2kΩ, 1/4W, ±5%	880086	01121	CB2025	3
R157	Same as R5				
R158	Same as R156				
R159	Resistor, Composition 360Ω, 1/4W, ±5%	880780	01121	CB3615	1
R160	Same as R3				
R166	Same as R26				
R168	Resistor, Composition 750Ω, 1/4W, ±5%	880602	01121	CB7515	1
R169	Same as R156				
R171	Same as R151				
R188[2]	Same as R26				1
R189[2]	Same as R3				1
R190	Resistor, Composition 75kΩ, 1/4W, ±5%	880821	01121	CB7535	1
R191[2]	Same as R54				
R192	Resistor, Composition 1.8Ω, 1/4W, ±5%	880642	01121	CB1825	1
R193	Same as R3				
R194[2]	Resistor, Composition 18kΩ, 1/4W, ±5%	880781	01121	CB1835	1
R196	Resistor, Composition 15kΩ, 1/4W, ±5%	880095	01121	CB1535	1
R197[1]	Resistor, Composition 620Ω, 1/4W, ±5%	880820	01121	CB6215	1
R198	Resistor, Composition 10Ω, 1/2W, ±5%	803074	01121	EB1005	1

[1] Used only on -3 & -4 assemblies.
[2] Used only on -2 & -4 assemblies.

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
R199	Same as R105				
R200	Same as R105				
R201	Resistor, Composition 11kΩ, 1/4W, ±5%	805279	QPL	RCR07G113JP	1
R202	Same as R43				
R203	Same as R43				
R204	Same as R43				
R206	Resistor, Composition 8.2kΩ, 1/4W, ±5%	880091	01121	CB8225	1
R207	Same as R90				
R208	Same as R3				
R209	Same as R61				
R210	Resistor, Composition 910kΩ, 1/4W, ±5%	804325	01121	CB9145	1
R211	Resistor, Composition 20Ω, 1/4W, ±5%	882271	QPL	RCR07G200JP	1
U2	Integrated Circuit	880061	unrest.	7427N	1
U3	Integrated Circuit	880057	unrest.	7404N	6
U4	Integrated Circuit	880067	unrest.	74123N	4
U5	Integrated Circuit	883740	unrest.	74LS76	1
U6	Integrated Circuit	880028	unrest.	74132N	1
U7	Same as U4				
U8	Integrated Circuit	880055	unrest.	7400N	1
U9	Same as U3				
U10	Integrated Circuit Res. 20k	880808	73138	899-1R20K	2
U11	Integrated Circuit	880655	01295	TID142N	2
U12	Integrated Circuit	880114	04713	MC1733CL	1
U14	Integrated Circuit	880113	04713	MC1414L	1
U15	Integrated Circuit	880336	unrest.	7416N	1
U16	Integrated Circuit	880024	14713	LM301AN	1
U17	Integrated Circuit	880654	04713	MPQ2907	2
U18	Integrated Circuit	880652	01295	SN74LS139	1
U19	Integrated Circuit	880140	unrest.	SN7417N	1
U20	Same as U3				

Replacement Parts List - Servo/Data Board - 786045-1, -2, -3, -4 (Continued)

Ref. Des.	Description	NAI Part No.	Mfr. Code	Mfr. Part No.	Total Qty
U21	Same as U3				
U22	Integrated Circuit	880059	unrest.	7408N	1
U23	Integrated Circuit	880049	04713	MC1458	3
U24	Same as U23				
U25	Same as U23				
U26	Same as U4				
U28	Same as U3				
U29	Integrated Circuit	880651	01295	SN7426N	2
U30	Same as U29				
U31	Integrated Circuit	880653	01295	SN7451N	2
U32	Integrated Circuit	880824	73138	8993R620	1
U33[1]	Same as U29				
U35	Same as U10				
U36	Integrated Circuit	880110	04713	MC1741	1
U38	Same as U17				
U39	Same as U11				
U40	Same as U3				
U41	Same as U31				
U42	Same as U4				

[1]Used only on -3 & -4 assemblies.

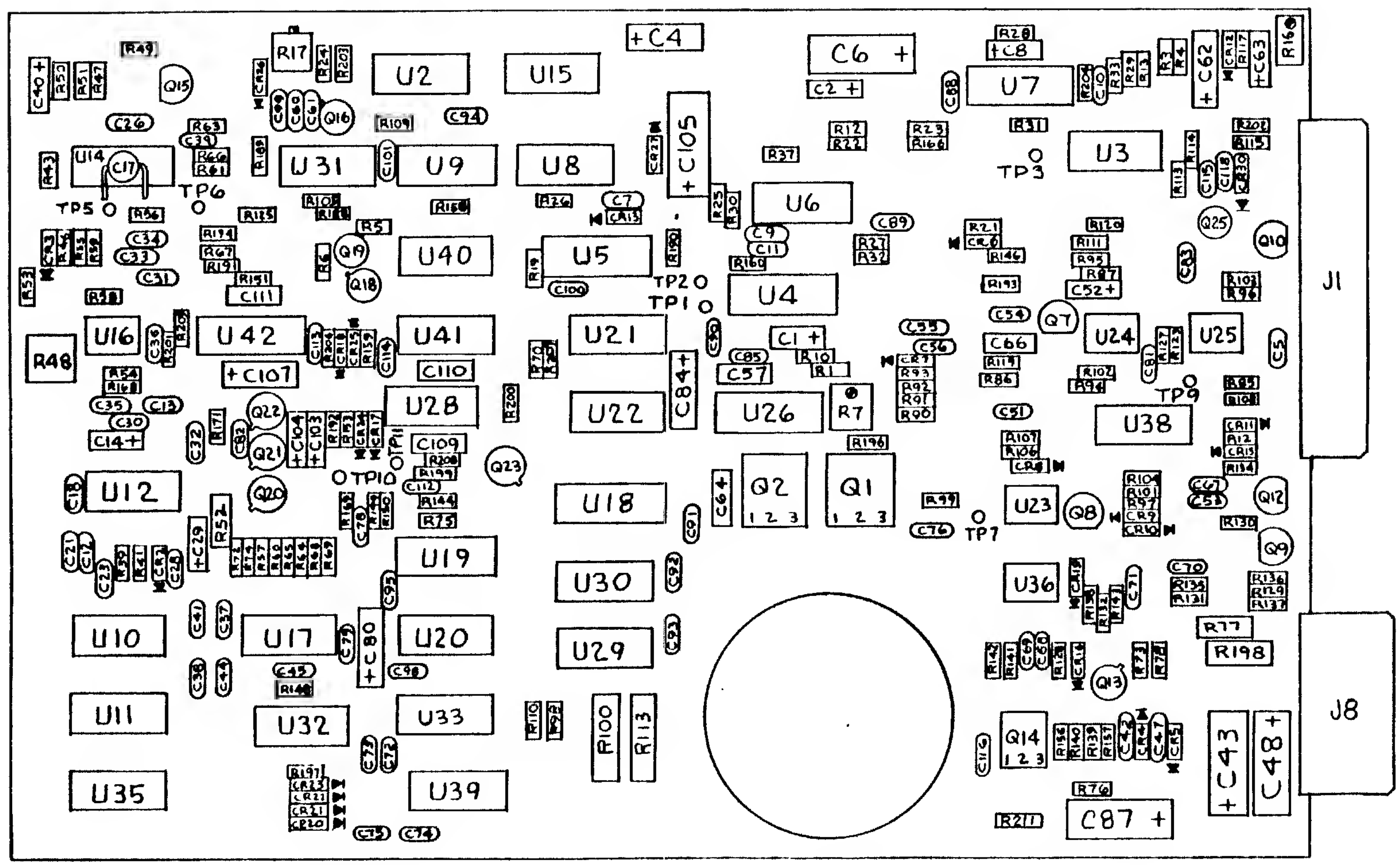


Figure 8-5. Servo/Data Board, Parts Locator

Replacement Parts List: Control Board Assembly - 786098

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
A4A	Control Board Assembly	786098			
C1	Capacitor, Ceramic, .05μf, 10V, +80 -20%	880116	71590	UK10-503	12
C2	Capacitor, Ceramic, .001μf, 1000V, ±10%	880038	72982	801-000-X5F0-102K	5
C3	Capacitor, Ceramic, .1μf, 25V, +80 -20%	880032	72982	5815-000-Y5U0-104Z	1
C4	Capacitor, Ceramic, .01μf, 25V, +80 -20%	880034	72982	5835-000-Y5U0-103Z	3
C5	Capacitor, Elect. Tant., 22μf, 15V	880133	06751	TS2K-15-226	2
C6	Same as C1				
C8	Same as C4				
C9	Same as C1				
C10	Same as C1				
C11	Capacitor, Ceramic, .02μf, 25V, +80 -20%	880035	72982	5835-000-Y5U0-	1
C12	Same as C1				
C13	Same as C4				
C14	Same as C1				
C15	Same as C2				
C16	Same as C1				
C17	Same as C5				
C18	Same as C2				
C19	Same as C2				
C20	Capacitor, Elect. Tant., 100μf, 10V, ±20%	880075	06751	TS3K-10-107	1
C29	Same as C1				
C30	Same as C1				
C31	Same as C1				
C32	Same as C1				
C33	Same as C1				
C34	Same as C2				
CR1	Diode, 1N4154	880052	04713	1N4154	1
J2	Socket, Strip	880006	50625	742-20	2
R1	Resistor, Composition, 220Ω, 1/4W, ±5%	880078	01121	CB2215	4

Replacement Parts List: Control Board Assembly - 786098 (Continued)

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
R2	Resistor, Composition, 4.7KΩ, 1/4W, ±5%	880088	01121	CB4725	5
R3	Resistor, Composition, 330Ω, 1/4W, ±5%	880080	01121	CB3315	2
R4	Same as R2				
R6	Resistor, Composition, 1KΩ, 1/4W, ±5%	880084	01121	CB1025	3
R8	Same as R3				
R9	Same as R2				
R10	Same as R2				
R13	Same as R1				
R14	Same as R6				
R15	Same as R2				
R16	Same as R1				
R17	Same as R1				
R18	Same as R6				
R19	Resistor, Composition, 15KΩ, 1/4W, ±5%	880095	01121	CB1535	1
R20	Resistor, Composition, 75KΩ, 1/4W, ±5%	880821	01121	CB7535	1
U1	Integrated Circuit	880064	unrest.	7474N	1
U2	Integrated Circuit	880063	unrest.	7438N	2
U3	Integrated Circuit	880057	unrest.	7404N	3
U4	Integrated Circuit	880062	unrest.	7432N	3
U5	Integrated Circuit	880068	unrest.	74279N	1
U6	Integrated Circuit	880059	unrest.	7408N	6
U7	Same as U6				
U8	I.C., Resistor (NOT USED WITH OPTION 2T)	880018	73138	899-5R 220/330	1
U9	Same as U2				
U10	Integrated Circuit	880055	unrest.	7400N	2
U11	Integrated Circuit	880065	unrest.	7476N	2
U12	Integrated Circuit	880061	unrest.	7427N	2
U13	Switch, 7 x SPST (NOT USED ON OPTION 1S, XS)	880134	00779	435166-1	1

Replacement Parts List: Control Board Assembly - 786098 (Continued)

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
U14	Same as U3				
U15	Same as U6				
U16	Same as U4				
U17	Integrated Circuit	880056	unrest.	7402N	1
U18	Same as U10				
U19	Same as U12				
U20	Same as U11				
U21	Same as U4				
U22	Same as U3				
U23	Same as U6				
U24	Same as U6				
U25	Same as U6				
XU8	I.C., Socket (NOT USED WITH OPTION 3T)	880166	01295	C931404	1

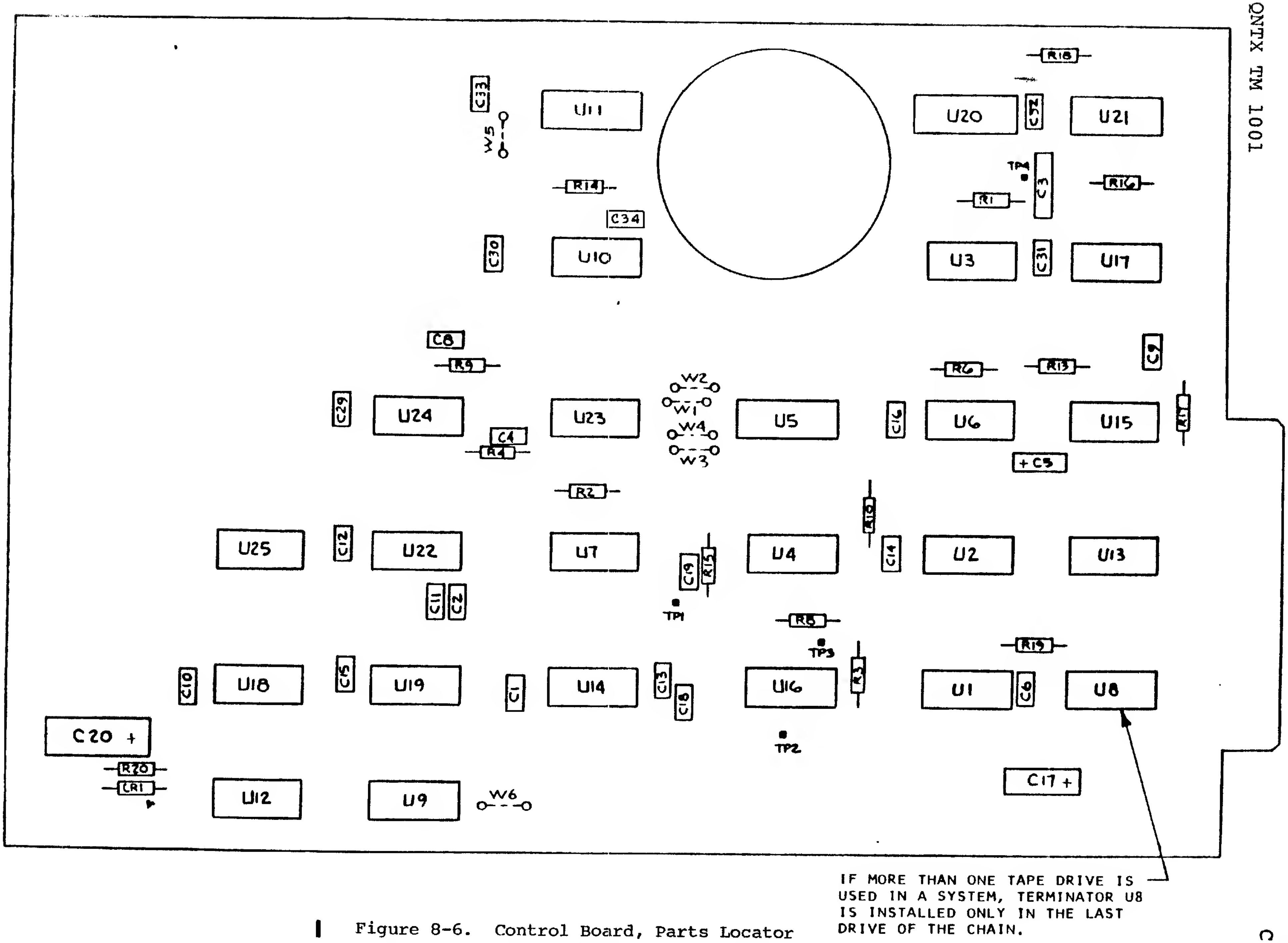


Figure 8-6. Control Board, Parts Locator

Replacement Parts List: Control Board w/Data Tracker Circuit - 786604

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
A4B	Control Board Assembly	786604			
C1	Capacitor, Ceramic, .05µf, 10V, +80 -20%	880116	71590	UK10-503	17
C2	Capacitor, Ceramic, .001µf, 1000V, ±10%	880038	72982	801-000-X5F0-102K	5
C3	Capacitor, Ceramic, .1µf, 25V, +80 -20%	880032	72982	5815-000-Y5U-0104Z	1
C4	Capacitor, Ceramic, .01µf, 25V, +80 -20%	880034	72982	5835-000-Y5U-0103Z	3
C5	Capacitor, Elect. Tant., 22µf, 15V	880133	06751	RS2K-15-226	2
C6	Same as C1				
C8	Same as C4				
C9	Same as C1				
C10	Same as C1				
C11	Capacitor, Ceramic, .02µf, 25V, +80 -20%	880035	72982	5835-000-Y5U-0203Z	1
C12	Same as C1				
C13	Same as C4				
C14	Same as C1				
C15	Same as C2				
C16	Same as C1				
C17	Same as C5				
C18	Same as C2				
C19	Same as C2				
C20	Capacitor, Elect. Tant., 100µf, 10V, ±20%	880075	06751	TS3K-10-107	1
C21	Capacitor, Ceramic, 50pf, 500V, ±5%	883077	72982	801-000-U2J0-500J	3
C22	Same as C21				
C23	Same as C1				
C24	Capacitor, Fixed Film, .022µf, 80V, ±10%	803249	56289	192P2239R8	1
C25	Capacitor, Fixed Film, .0056µf, 80V, ±10%	803348	56289	192P5629R8	1
C26	Capacitor, Fixed Film, .0033µf, 80V, ±20%	803865	56289	192P3320R8	1
C27	Capacitor, Ceramic, 220pf, 500V, ±10%	883163	72982	831-000-X5F0-221K	1

Replacement Parts List: Control Board w/Data Tracker Circuit - 786604 (Continued)

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
C28	Same as C21				
C29	Same as C1				
C30	Same as C1				
C31	Same as C1				
C32	Same as C1				
C33	Same as C1				
C34	Same as C1				
C35	Same as C1				
C36	Same as C1				
C37	Same as C1				
C38	Same as C2				
CR1	Diode, 1N4154	880052	04713	1N4154	1
J2	Socket, Strip	880006	50625	742-20	2
Q1	Transistor	880124	07263	2N2907	1
Q2	Transistor	880715	04713	2N2222	1
R1	Resistor, Composition, 220Ω, 1/4W, ±5%	880078	01121	CB2215	4
R2	Resistor, Composition, 4.7KΩ, 1/4W, ±5%	880088	01121	CB4725	5
R3	Resistor, Composition, 330Ω, 1/4W, ±5%	880080	01121	CB3315	2
R4	Same as R2				
R6	Resistor, Composition, 1KΩ, 1/4W, ±5%	880084	01121	CB1025	4
R8	Same as R3				
R9	Same as R2				
R10	Same as R2				
R13	Same as R1				
R14	Same as R6				
R15	Same as R2				

Replacement Parts List: Control Board w/Data Tracker Circuit - 786604 (Continued)

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
R16	Same as R1				
R17	Same as R1				
R18	Same as R6				
R19	Resistor, Composition, 15KΩ, 1/4W, ±5%	880095	01121	CB1535	1
R20	Resistor, Composition, 75KΩ, 1/4W, ±5%	880821	01121	CB7535	1
R21	Resistor, Composition, 10KΩ, 1/4W, ±5%	880092	01121	CB1035	5
R22	Same as R21				
R23	Same as R21				
R24	Resistor, Composition, 100KΩ, 1/4W, ±5%	880846	01121	CB1045	1
R25	Same as R6				
R26	Resistor, Composition, 6.8KΩ, 1/4W, ±5%	880090	01121	CB6825	1
R27	Resistor, Composition, 51KΩ, 1/4W, ±5%	882399	QPL-39008	RCR07G513JP	1
R28	Potentiometer, 10KΩ	883144	11869	850W-10K	1
R29	Same as R21				
R30	Same as R21				
R31	Resistor, Composition, 510Ω, 1/4W, ±5%	880082	01121	CB5115	1
U1	Integrated Circuit	880064	unrest.	7474N	2
U2	Integrated Circuit	880063	unrest.	7438N	3
U3	Integrated Circuit	880057	unrest.	7404N	3
U4	Integrated Circuit	880062	unrest.	7432N	3
U5	Integrated Circuit	880068	unrest.	74279N	1
U6	Integrated Circuit	880059	unrest.	7408N	6
U7	Same as U6				
U8	I.C., Resistor (NOT USED WITH OPTION 2T)	880018	73138	899-5R 220/330	1
U9	Same as U2				
U10	Integrated Circuit	880055	unrest.	7400N	4
U11	Integrated Circuit	880065	unrest.	7476N	2
U12	Integrated Circuit	880061	unrest.	7427N	2
U13	Switch, 7 x SPST (NOT USED ON OPTION 1S, XS)	880134	00779	435166-1	1
R32	Resistor, Composition, 2.7KΩ, 1/4W, ±5%	880746	01121	CB2725	1
TR1	Thermistor	883298	91833	RL-2006-137-73	1

Replacement Parts List: Control Board w/Data Tracker Circuit - 786604 (Continued)

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
U14	Same as U3				
U15	Same as U6				
U16	Same as U4				
U17	Integrated Circuit	880056	unrest.	7402N	1
U18	Same as U10				
U19	Same as U12				
U20	Same as U11				
U21	Same as U4				
U22	Same as U3				
U23	Same as U6				
U24	Same as U6				
U25	Same as U10				
U26	Same as U10				
U27	Integrated Circuit	883152	01295	74160N	1
U28	Integrated Circuit	880067	unrest.	74123N	2
U29	Same as U28				
U30	Integrated Circuit	883160	01295	74123N	1
U31	Same as U1				
U32	Same as U6				
U33	Same as U2				
U34	Integrated Circuit	880271	unrest.	7486N	1
XU8	I.C., Socket (NOT USED WITH OPTION 3T)	880166	01295	C931402	1

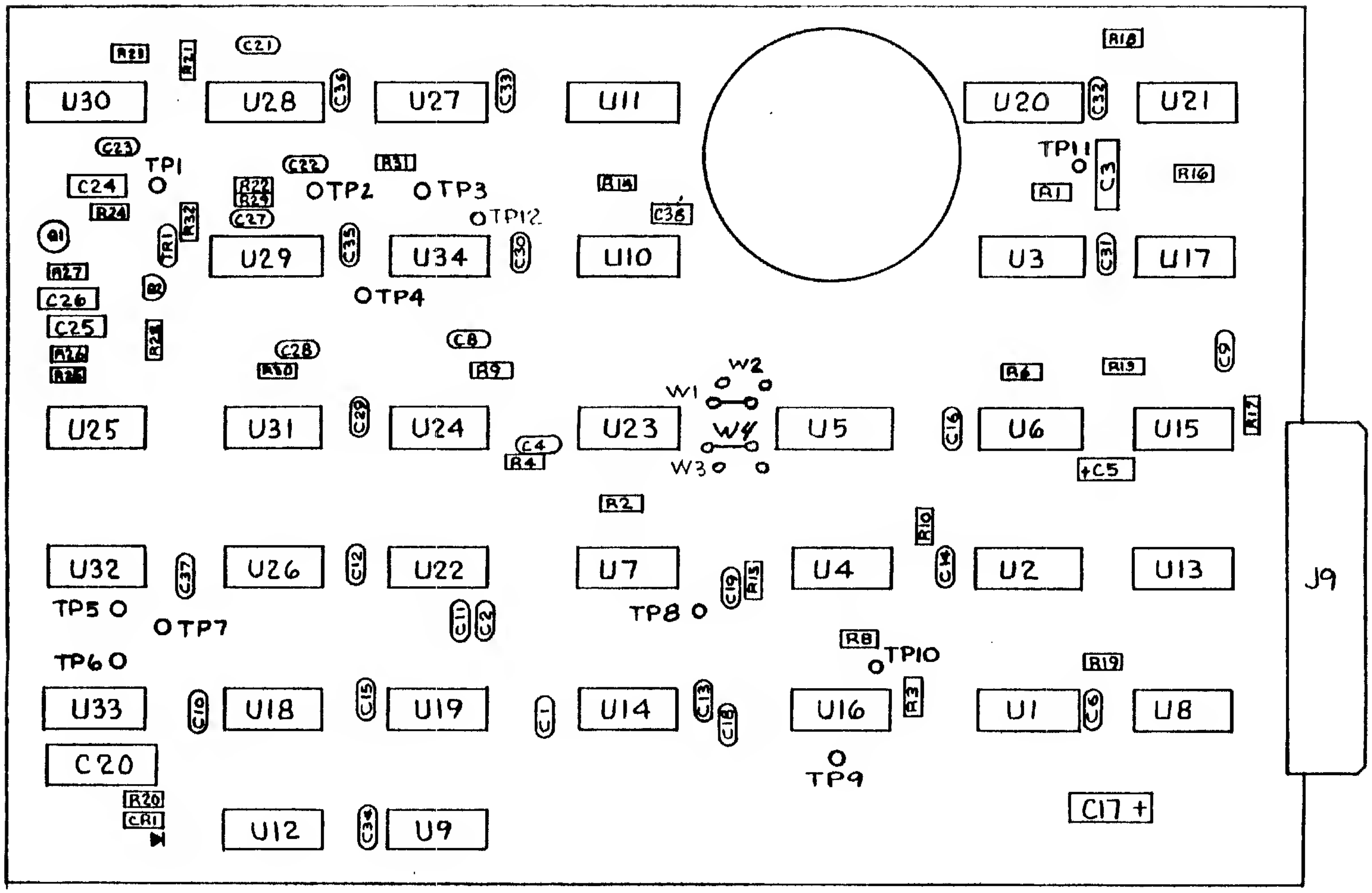


Figure 8-7. Control Board w/Data Tracker Circuit, Parts Locator

Replacement Parts List: LED Display Board Assembly - 786611

REF. DES.	DESCRIPTION	NAI PART NO.	MFR CODE	MFR PART NO.	TOTAL QTY
A5A	LED Display Board Assembly	786611			
C1	Capacitor, Elect. Tant., 4.7µf, 10V, ±20%	880072	06751	TS1K-10-475	1
DS1	LED (Light Emitting Diode)	883198	72619	549-0101	4
DS2	Same as DS1				
DS3	Same as DS1				
DS4	Same as DS1				
L1	Choke, 22µh, 500MA	882820		MS75089-3	1
Q1	Transistor	880124	07263	2N2907A	4
Q2	Same as Q1				
Q3	Same as Q1				
Q4	Same as Q1				
R1	Resistor, Composition, 330Ω, 1/4W, ±5%	880080	01121	CB3315	4
R2	Resistor, Composition, 1KΩ, 1/4W, ±5%	880084	01121	CB1025	4
R3	Resistor, Composition, 100Ω, 1/4W, ±5%	880077	01121	CB1015	4
R4	Same as R1				
R5	Same as R2				
R6	Same as R3				
R7	Same as R1				
R8	Same as R2				
R9	Same as R3				
R10	Same as R1				
R11	Same as R2				
R12	Same as R3				

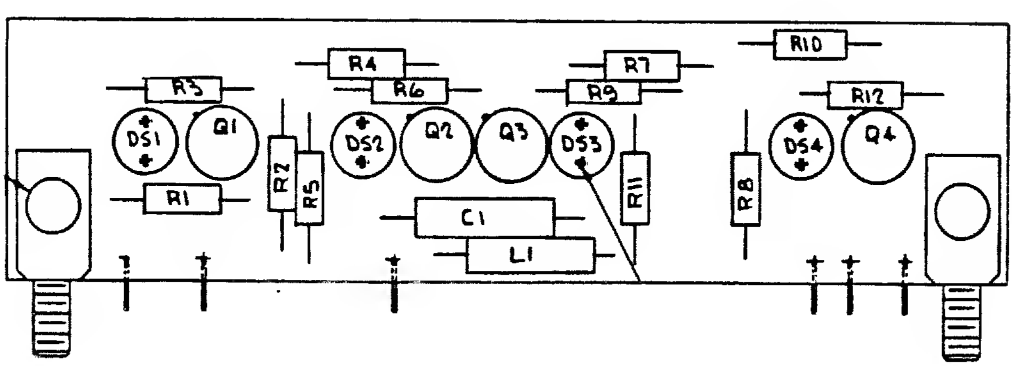


Figure 8-8. LED Display Board, Parts Locator

SECTION 9

UNIT SCHEMATICS

This section contains the schematic diagrams for all units of the tape drive.

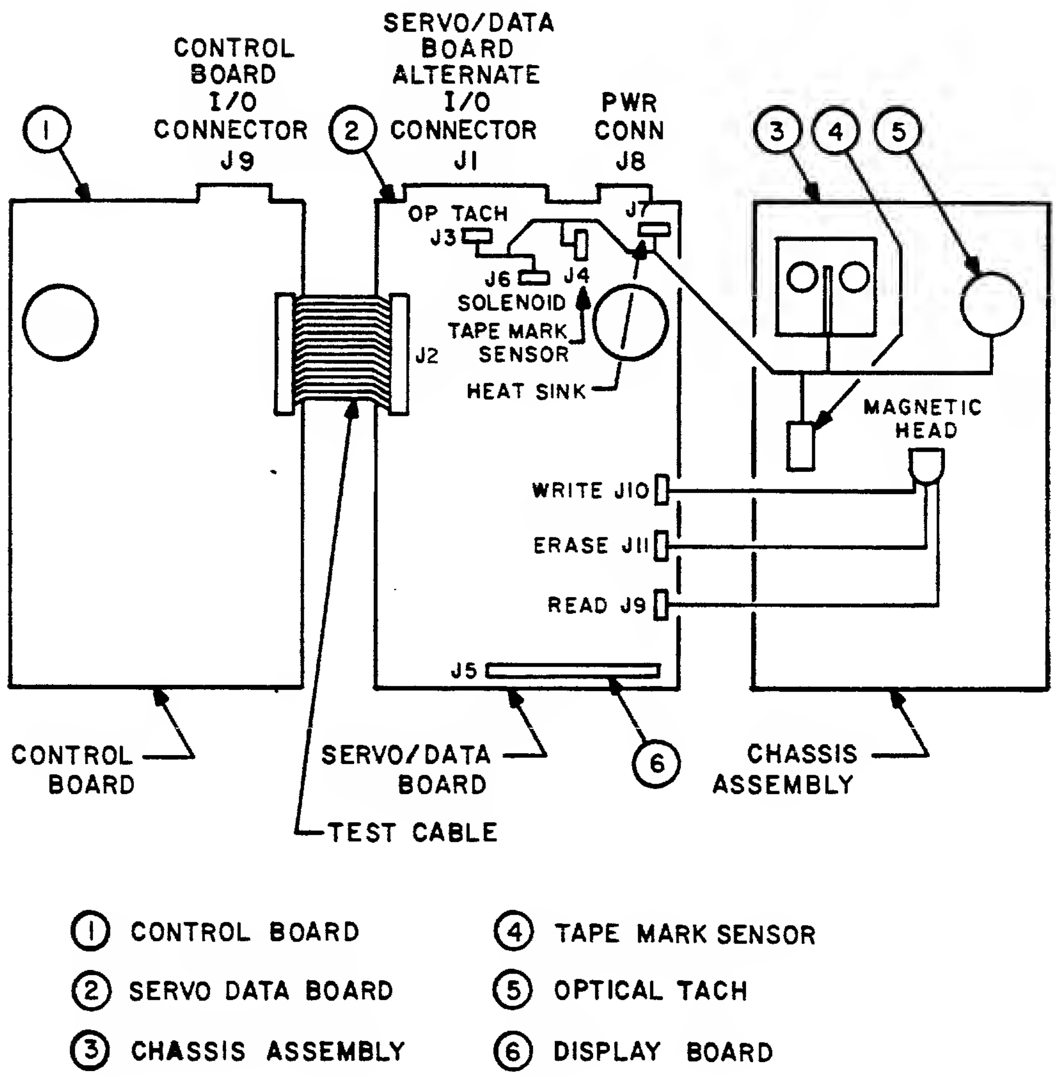


Figure 9-1. Model 650 Tape Drive, Interconnecting Diagram

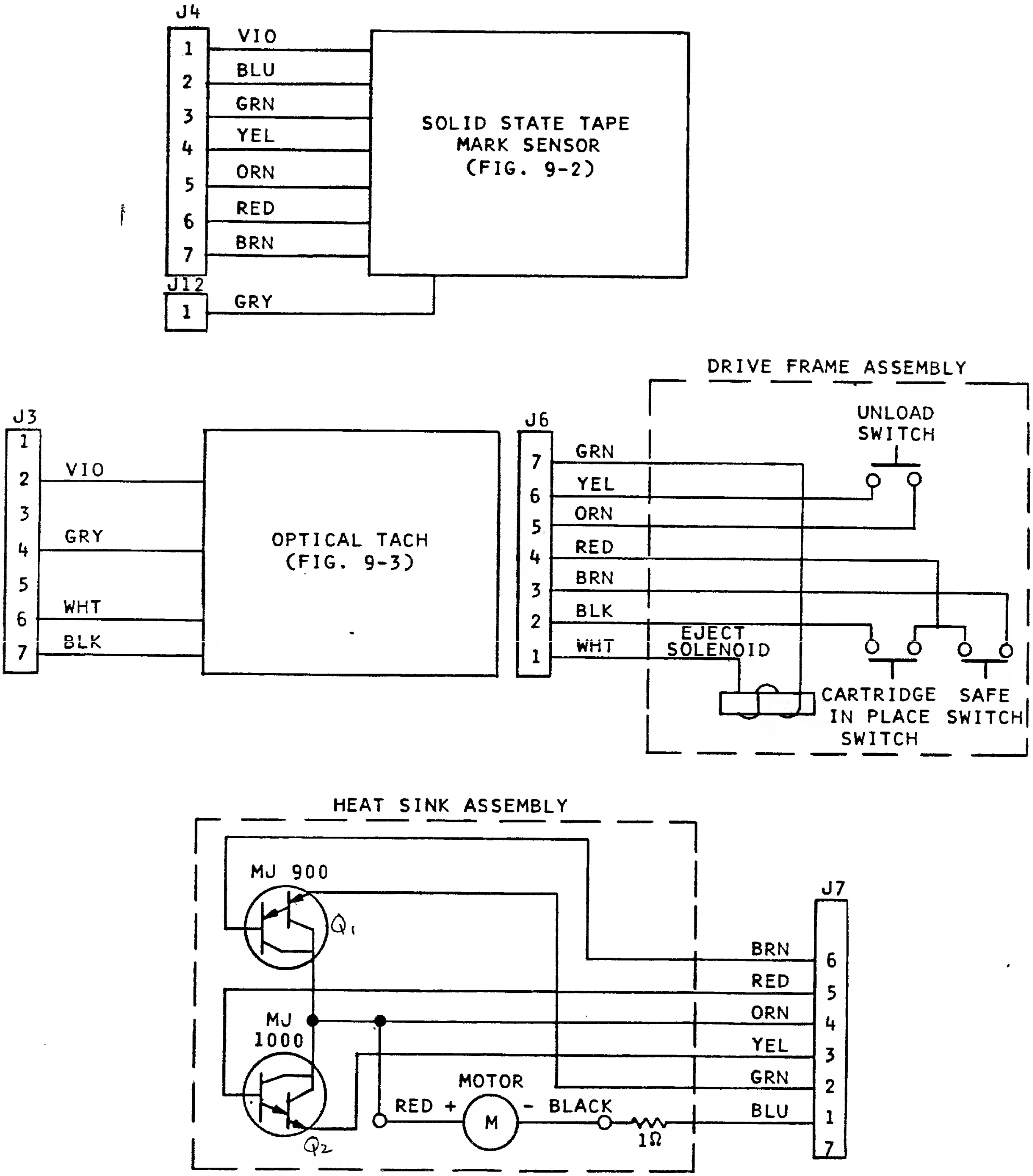


Figure 9-2. Model 650 Tape Drive Chassis Assembly, Schematic

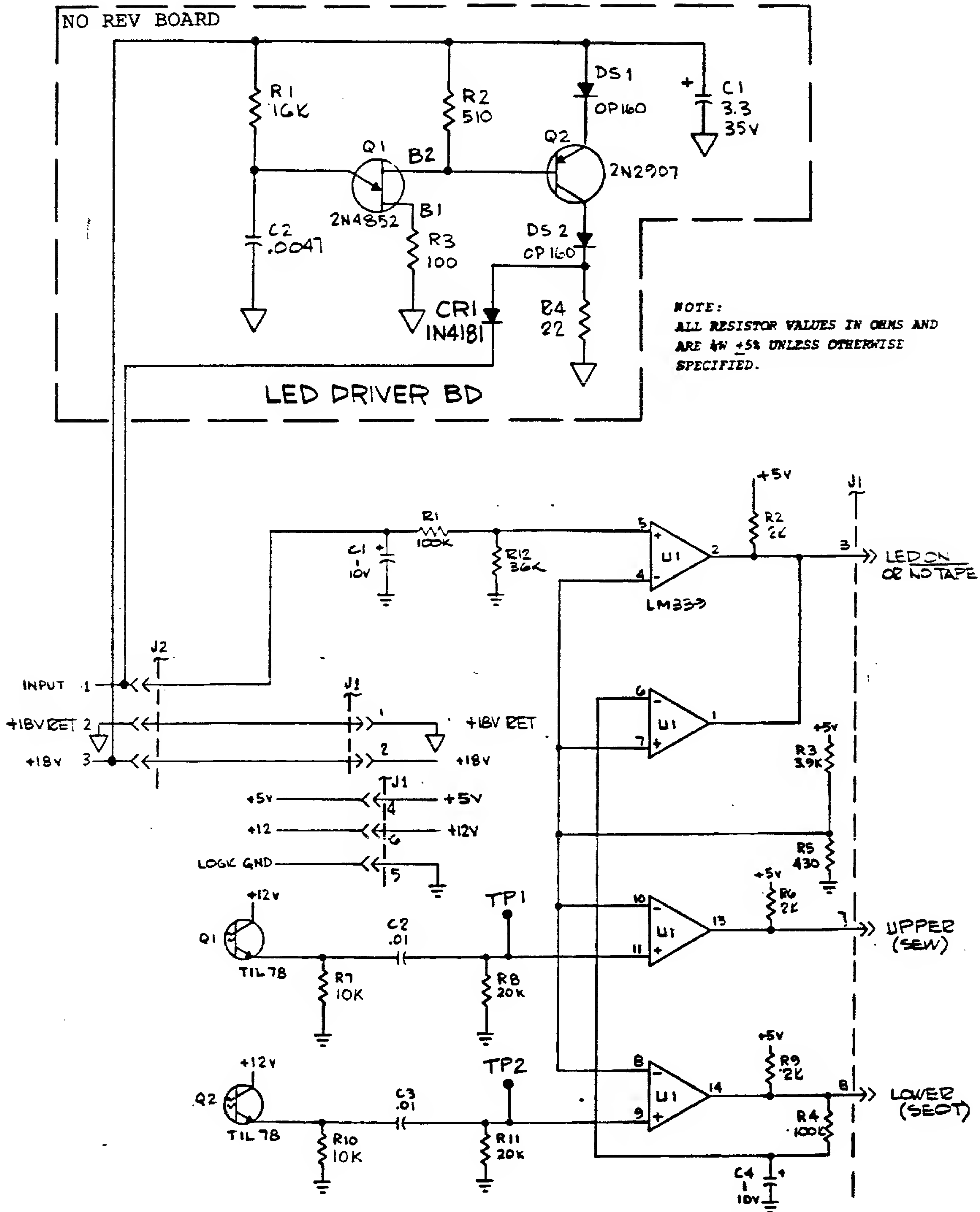
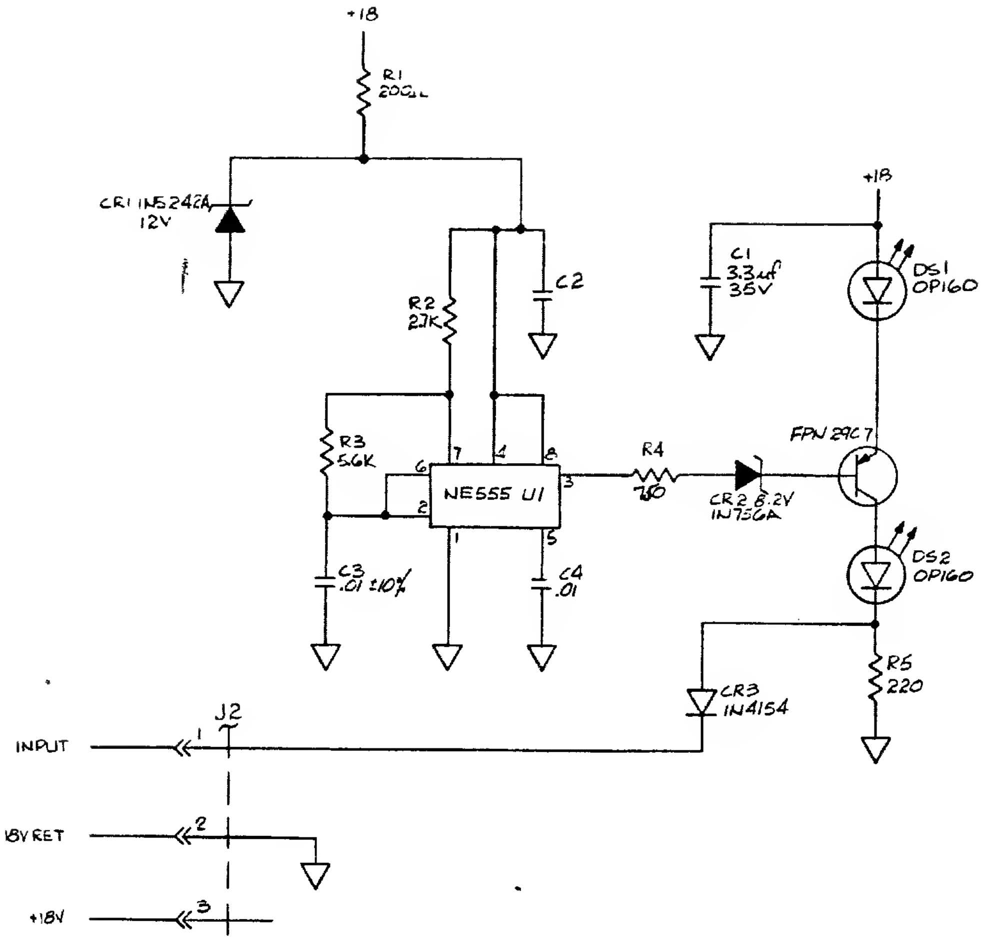
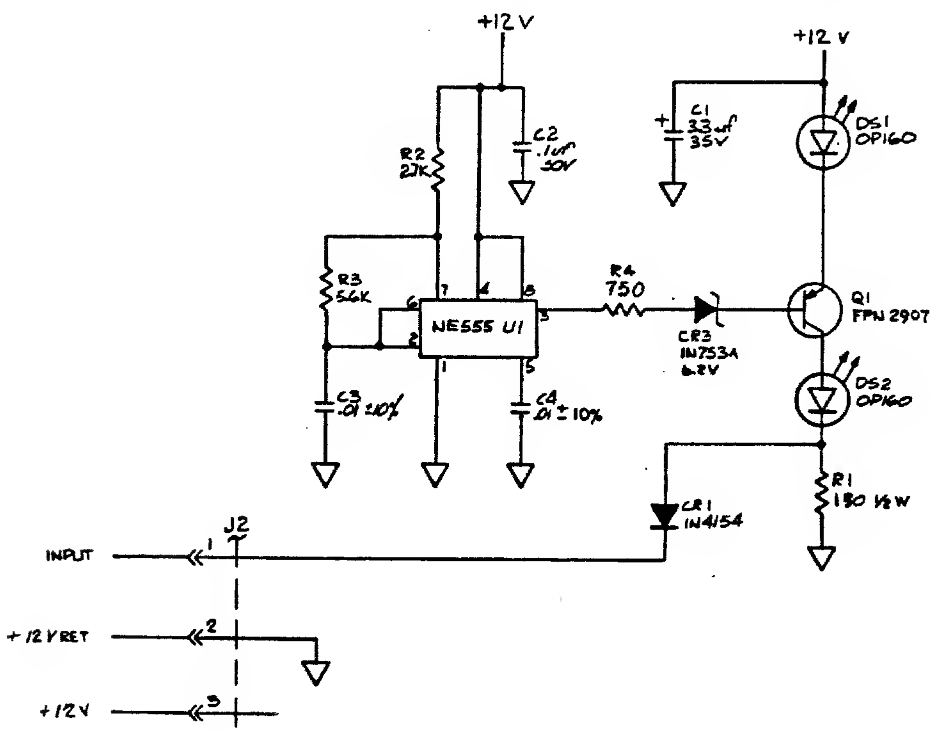


Figure 9-3. Solid State Tape Mark Sensor, Schematic (Sh. 1 of 2)



NOTE: (UNLESS OTHERWISE SPECIFIED)
1 - ALL RESISTOR VALUES IN OHMS AND ARE 1/4W, ±5%
2 - ALL CAPACITANCE VALUES ARE IN MICROFARADS.

Figure 9-3. LED Driver Board (18V) (Rev A and Up), Schematic (Sh. 2 of 2)



NOTE: (UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTOR VALUES IN OHMS AND ARE ¼W±5%.
2. ALL CAPACITANCE VALUES ARE IN MICROFARADS.
3. THIS DWG IS FOR ASSY 548064 USING PW BD 296273 REV'E' & UP.

Figure 9-3.1. LED Drive Board (12V), Schematic

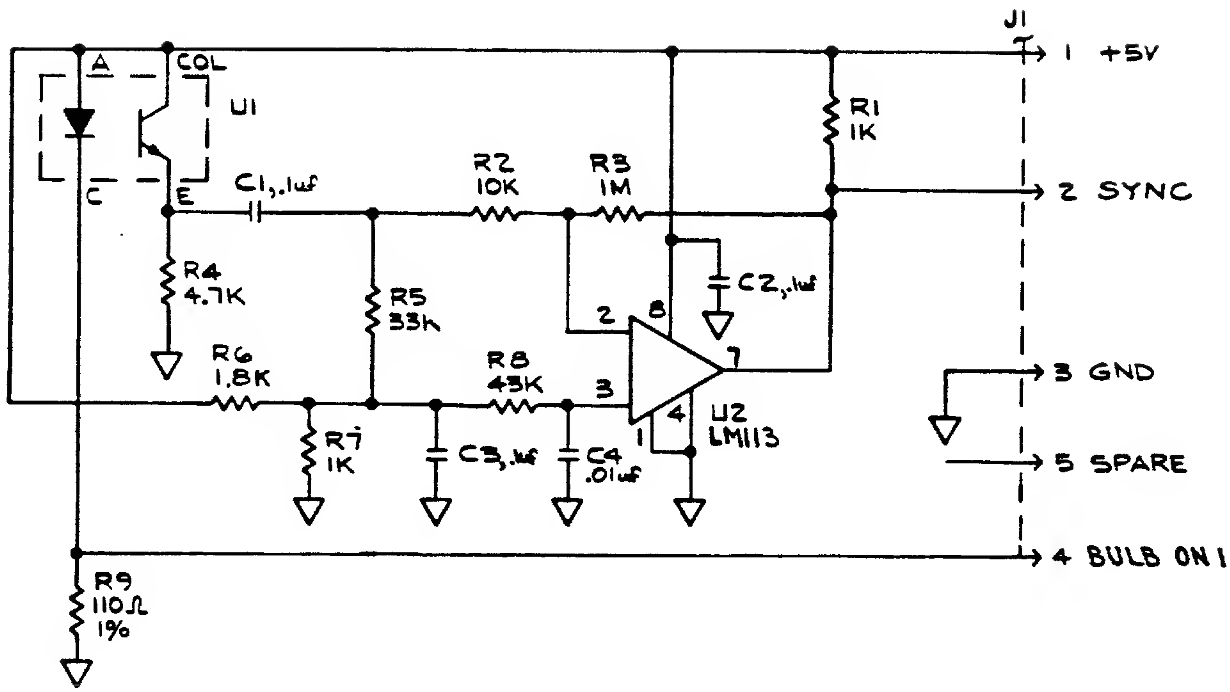
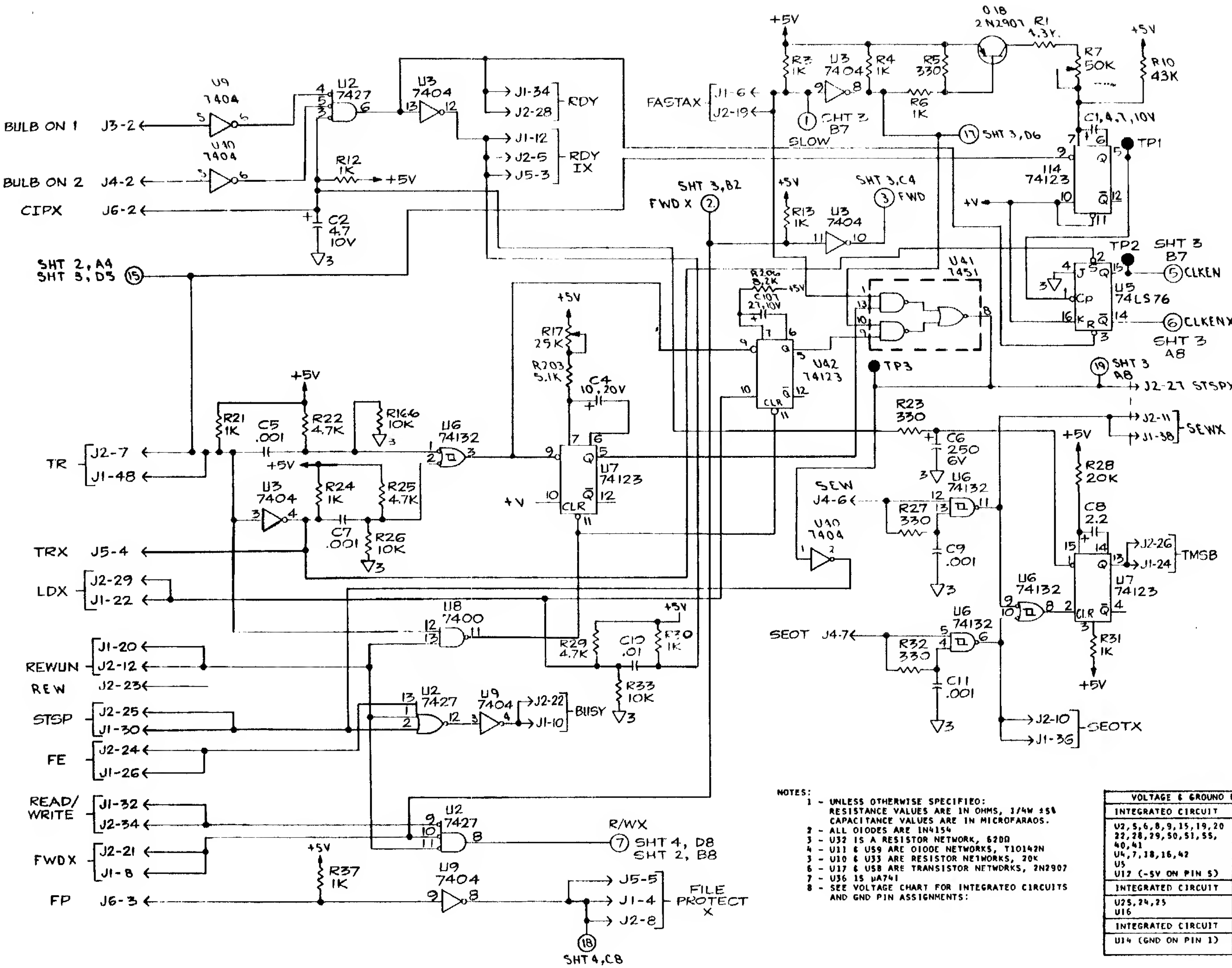


Figure 9-4. Optical Tachometer, Schematic



NOTES:

1 - UNLESS OTHERWISE SPECIFIED:
RESISTANCE VALUES ARE IN OHMS, 1/4W ±5%
CAPACITANCE VALUES ARE IN MICROFARADS.
2 - ALL DIODES ARE 1N4154
3 - U32 IS A RESISTOR NETWORK, 620Ω
4 - U11 & U59 ARE DIODE NETWORKS, TID142N
5 - U10 & U33 ARE RESISTOR NETWORKS, 20K
6 - U17 & U58 ARE TRANSISTOR NETWORKS, 2N2907
7 - U36 IS μA741
8 - SEE VOLTAGE CHART FOR INTEGRATED CIRCUITS AND GND PIN ASSIGNMENTS:

VOLTAGE & GROUND CHART		
INTEGRATED CIRCUIT	+5 V	GND
U2,5,6,8,9,15,19,20 22,28,29,30,31,35, 40,41	14	7
U4,7,18,16,42	16	8
U5	5	13
U17 (-5V ON PIN 5)	10	
INTEGRATED CIRCUIT	+12V	-12V
U23,24,25	8	4
U16	7	4
INTEGRATED CIRCUIT	+12V	-6V
U14 (GND ON PIN 1)	3 10	7 14

Figure 9-5. Servo/Data Board (Sheet 1 of 5) (Logic Circuits), Schematic

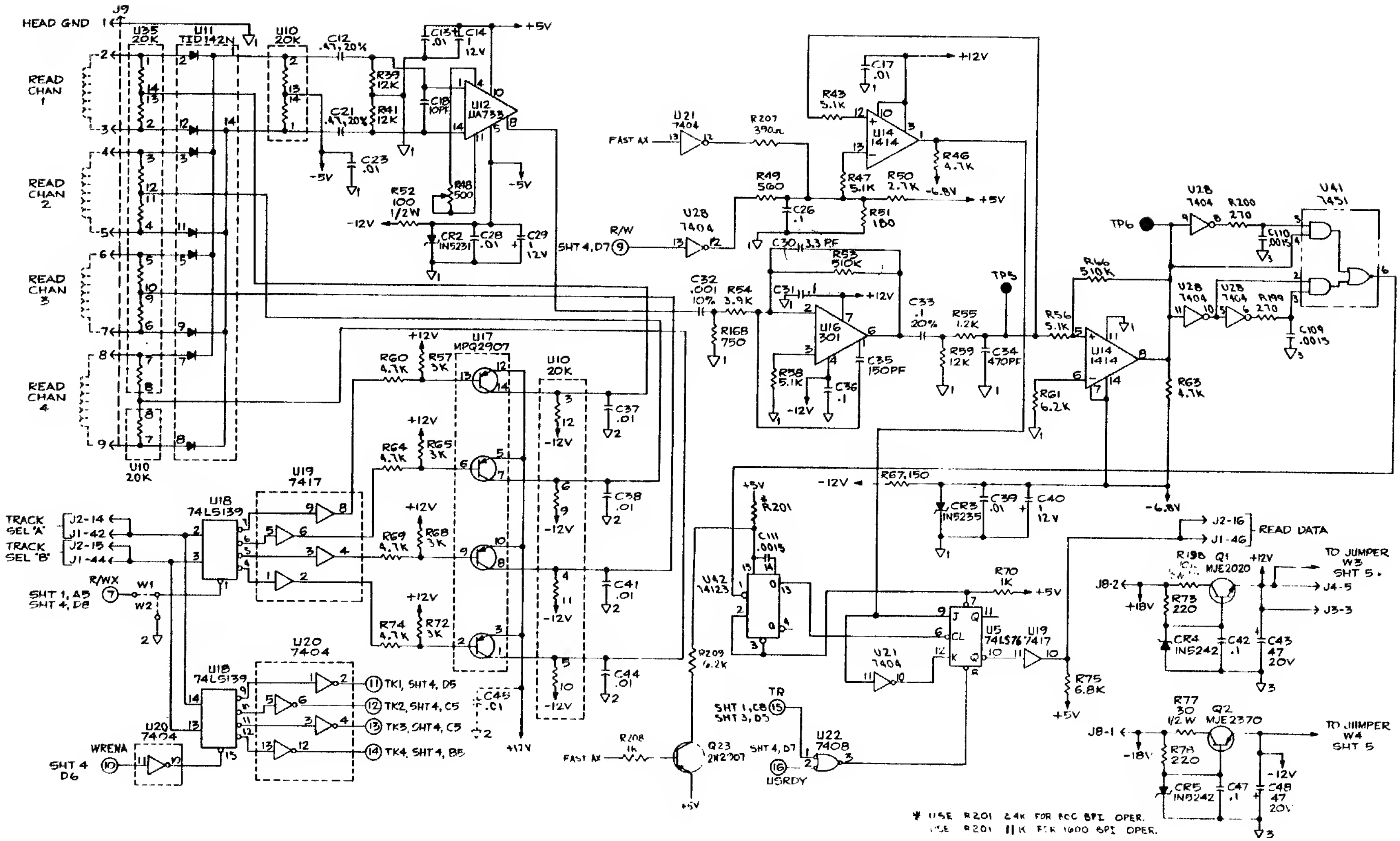


Figure 9-5. Servo/Data Board (Sheet 2 of 5) (Read Circuits), Schematic

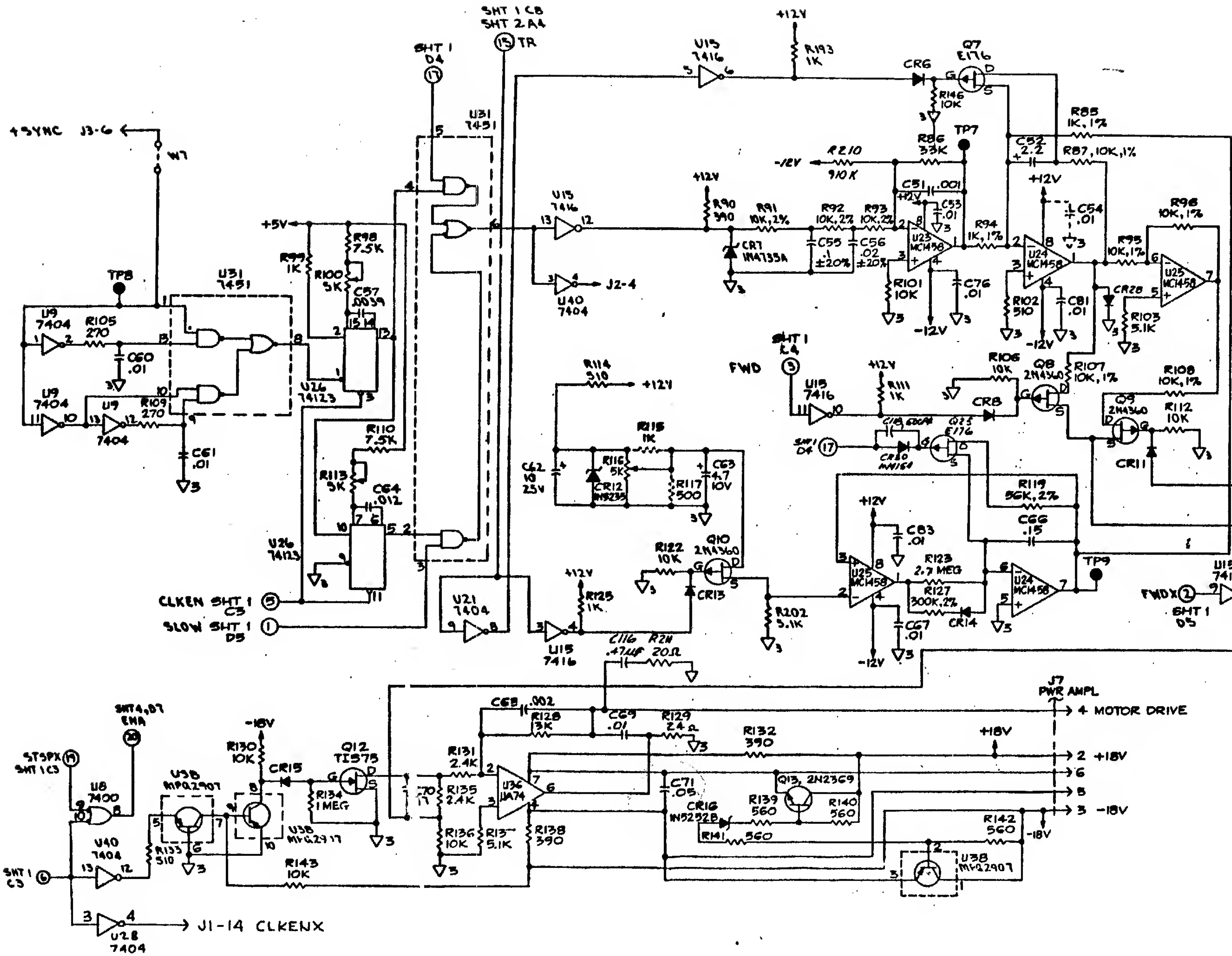


Figure 9-5. Servo/Data Board (Sheet 3 of 5) (Servo Amp), Schematic

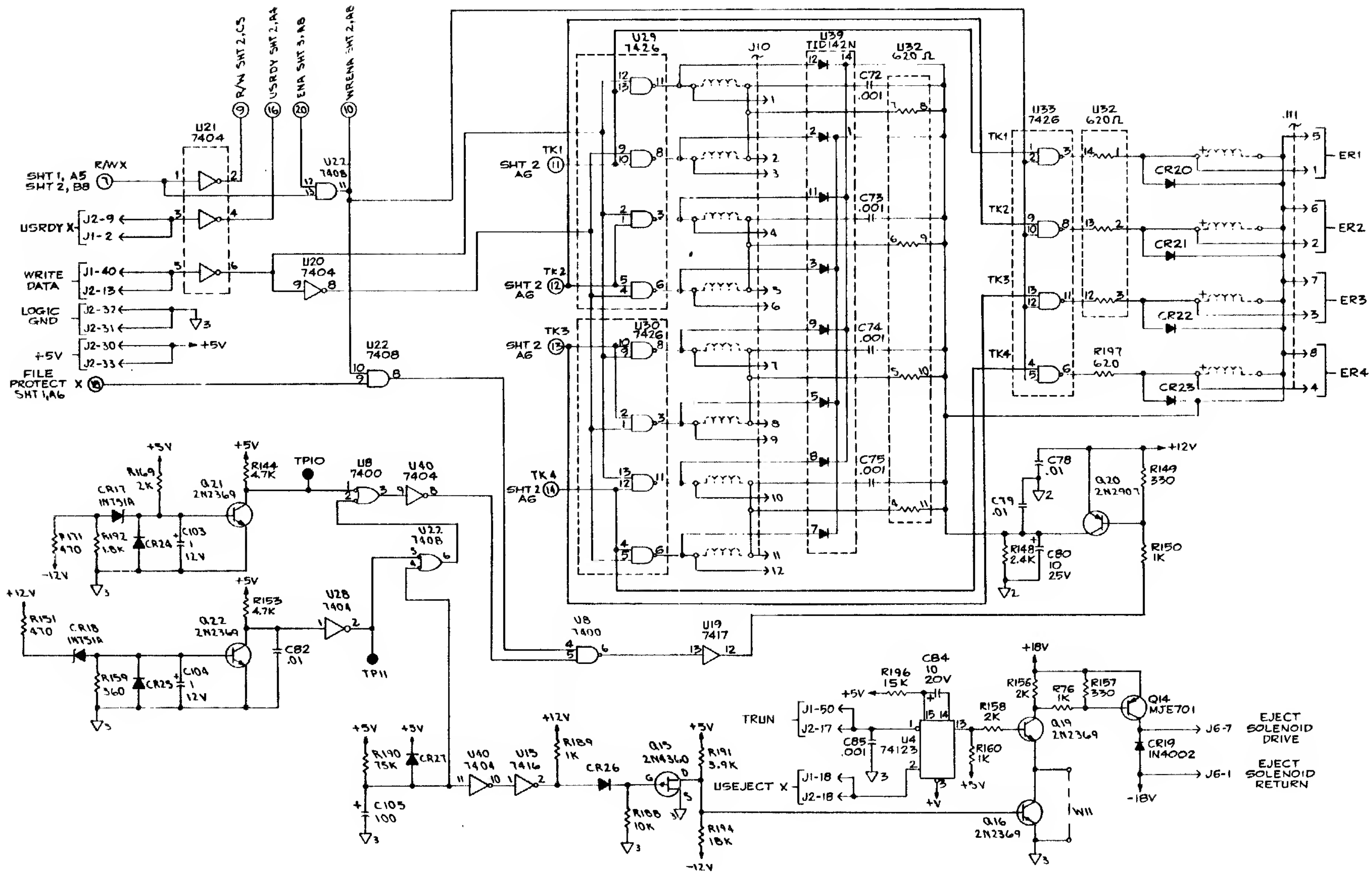


Figure 9-5. Servo/Data Board (Sheet 4 of 5) (Write/Erase), Schematic

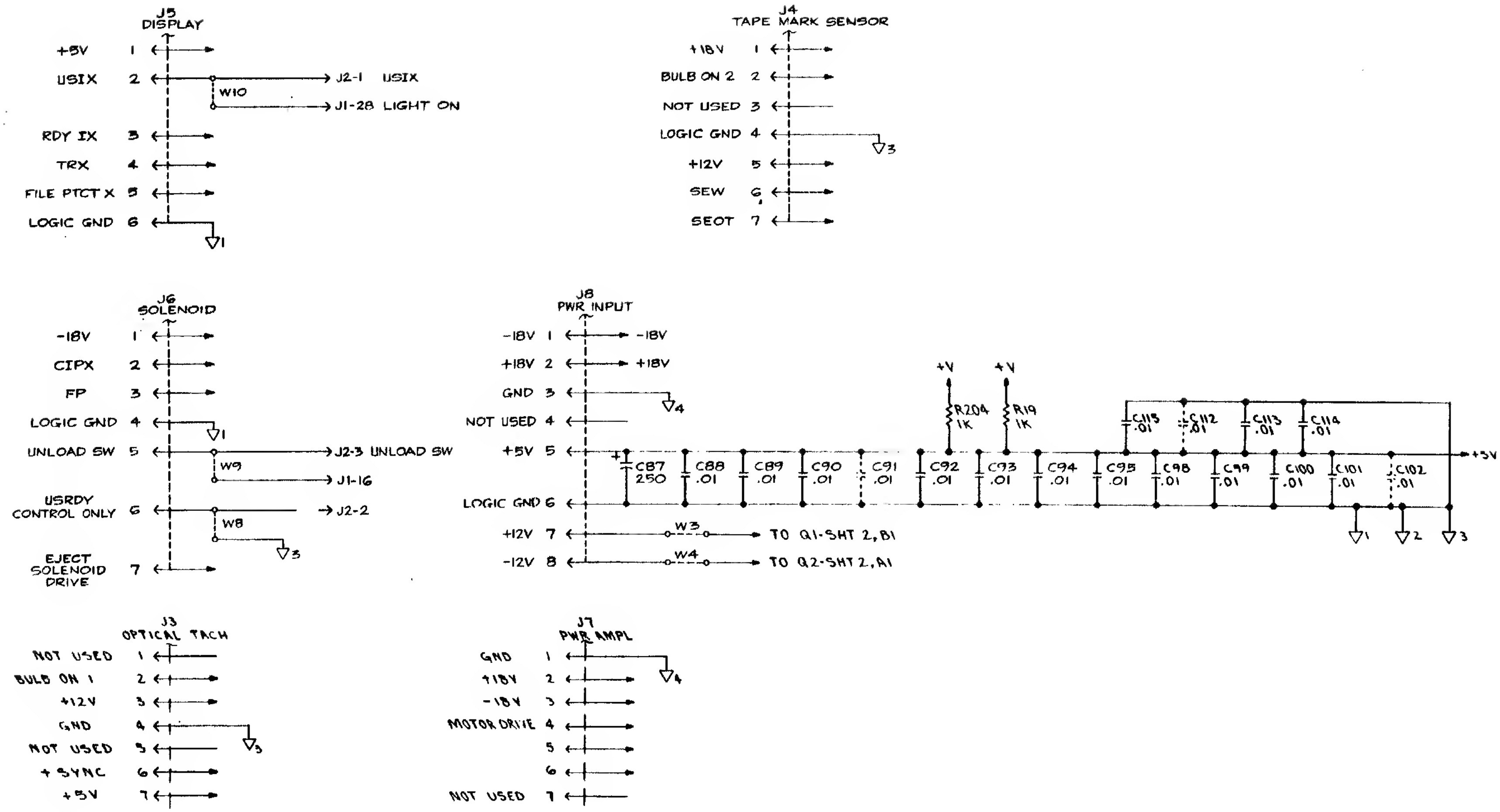
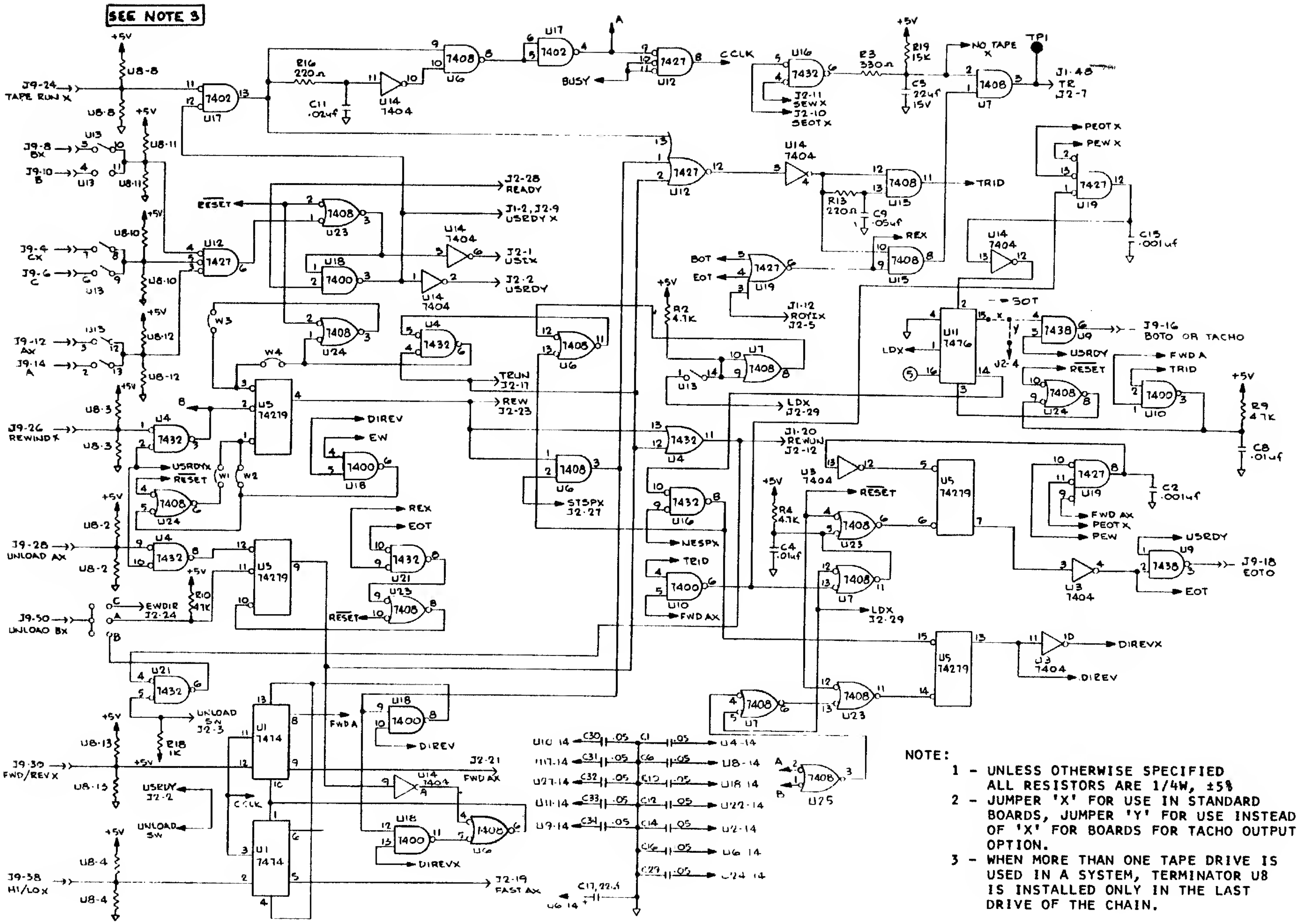


Figure 9-5. Servo/Data Board (Sheet 5 of 5) (J4,5,6, and J8), Schematic



NOTE:

1 - UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE 1/4W, ±5%

2 - JUMPER 'X' FOR USE IN STANDARD BOARDS, JUMPER 'Y' FOR USE INSTEAD OF 'X' FOR BOARDS FOR TACHO OUTPUT OPTION.

3 - WHEN MORE THAN ONE TAPE DRIVE IS USED IN A SYSTEM, TERMINATOR U8 IS INSTALLED ONLY IN THE LAST DRIVE OF THE CHAIN.

Figure 9-6. Control Board (Sheet 1 of 2), Schematic

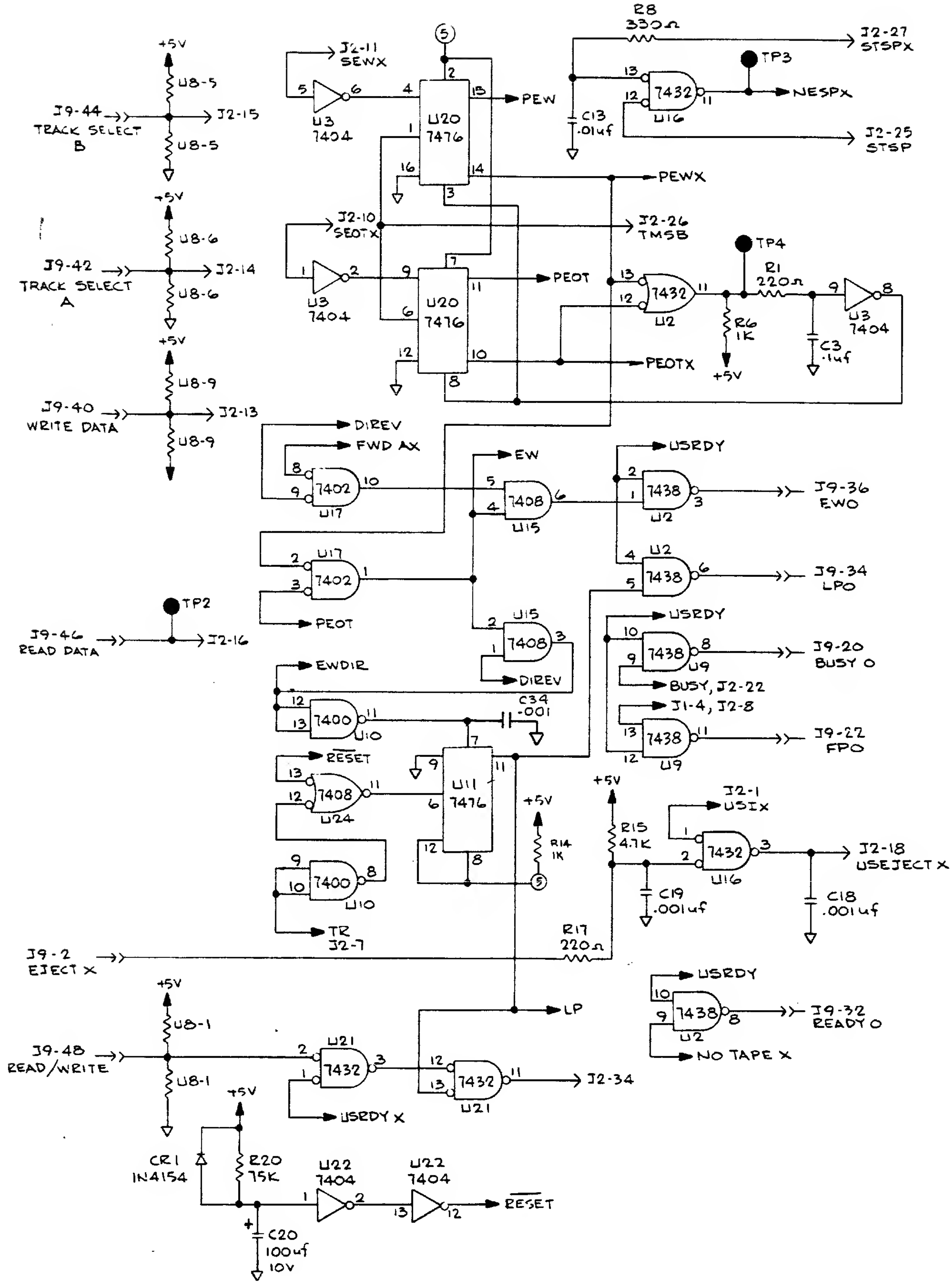
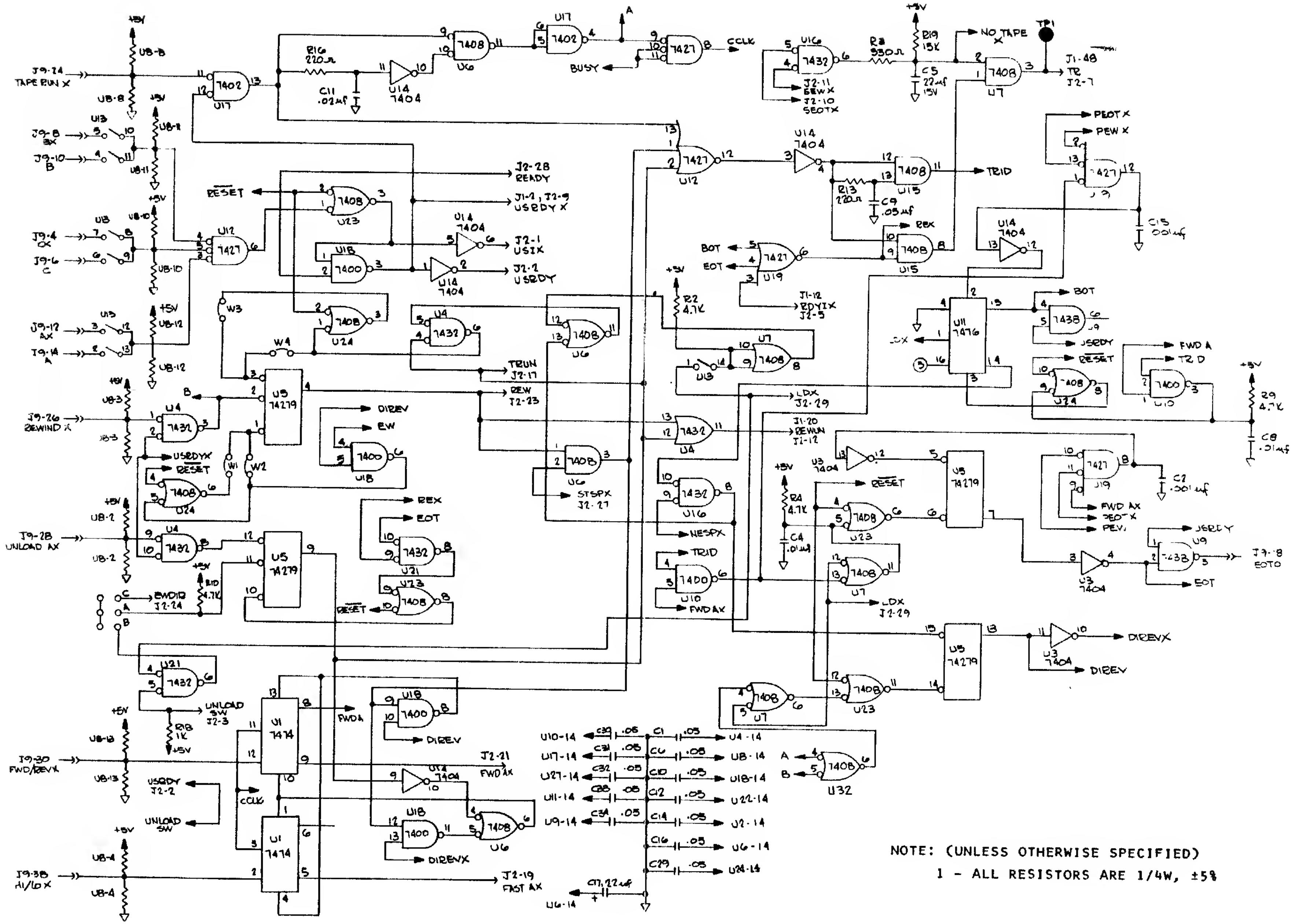


Figure 9-6. Control Board (Sheet 2 of 2), Schematic



NOTE: (UNLESS OTHERWISE SPECIFIED)
1 - ALL RESISTORS ARE 1/4W, ±5%

Figure 9-7. Control Board w/Data Tracker Circuit (Sheet 1 of 2), Schematic

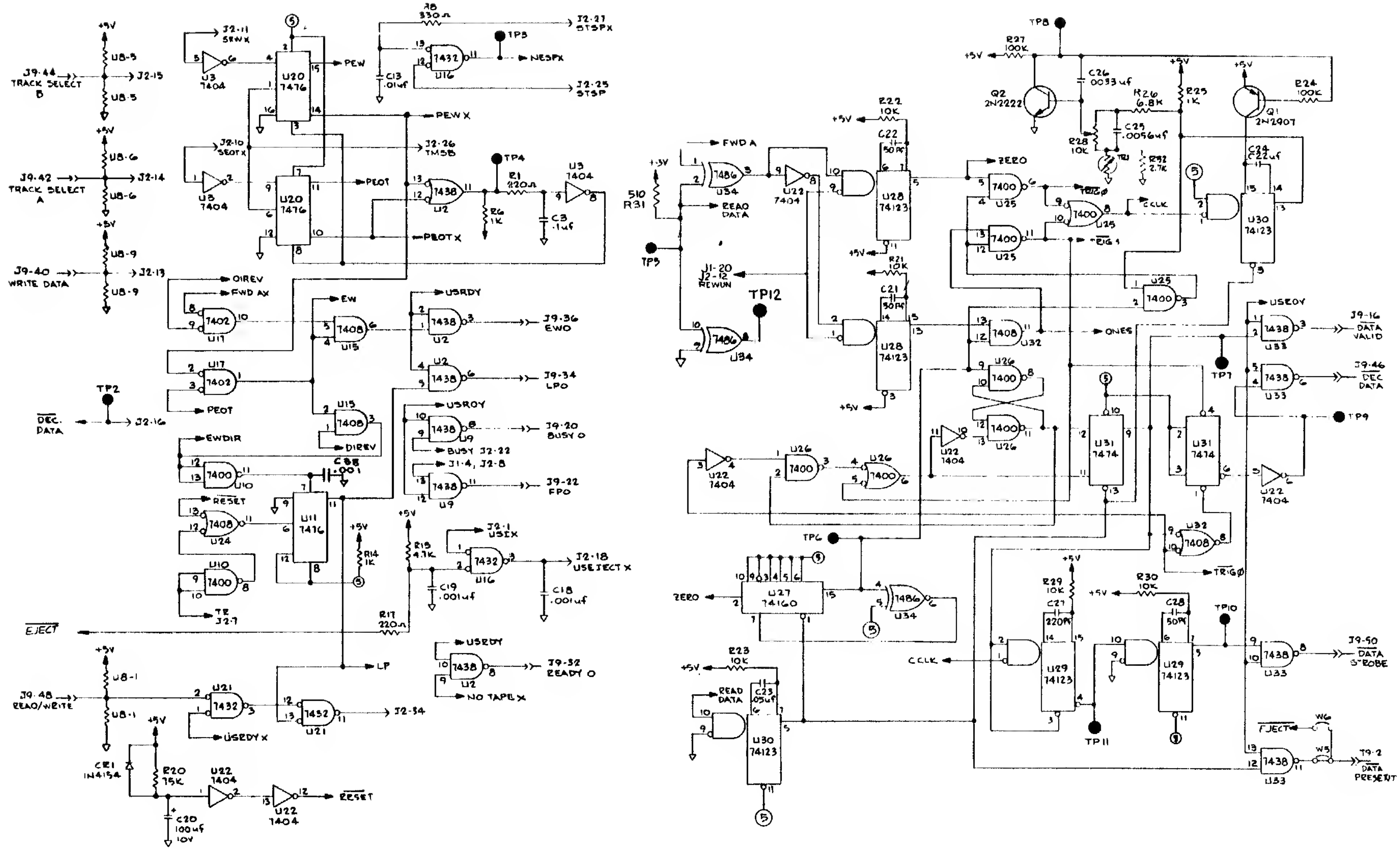
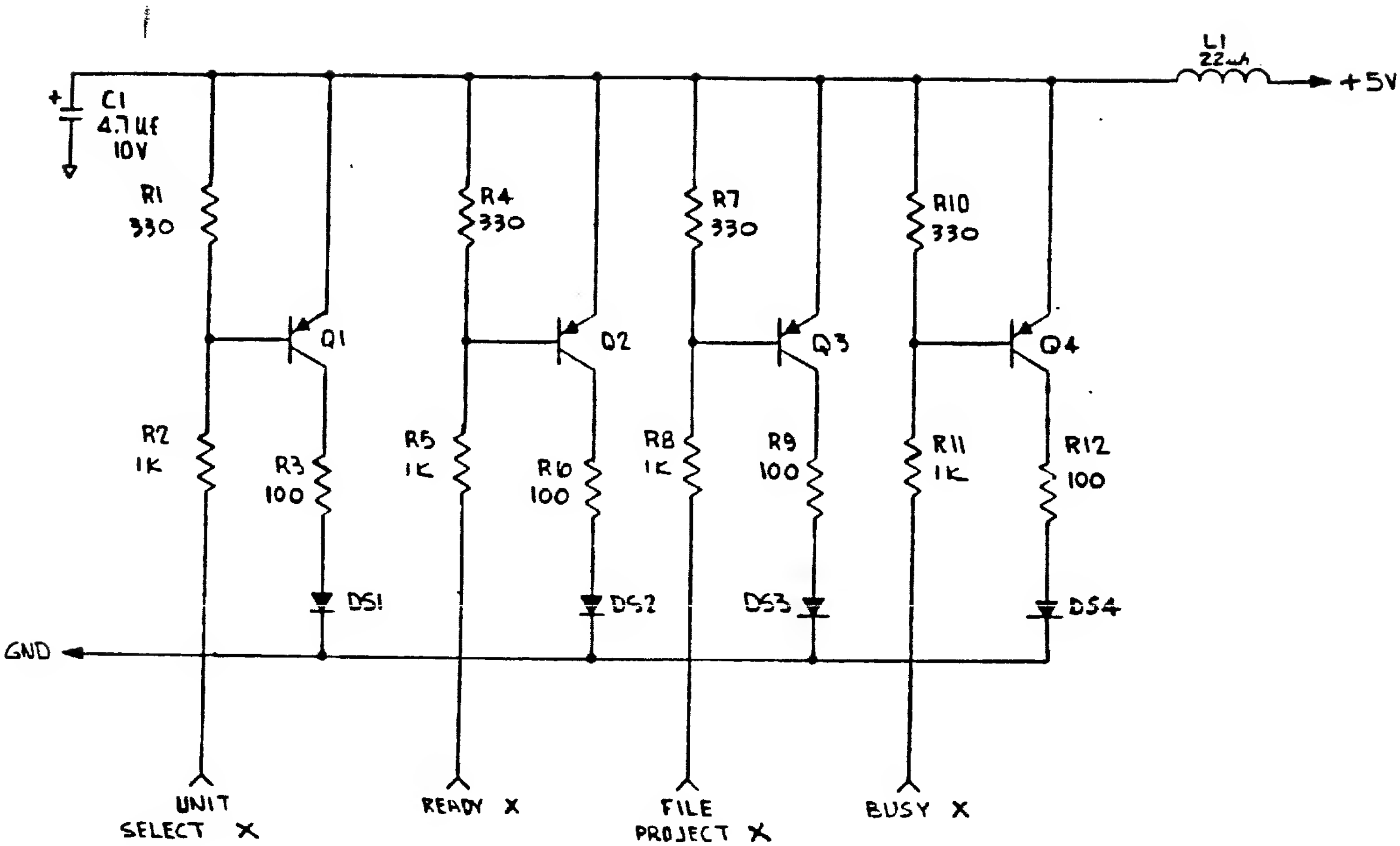


Figure 9-7. Control Board w/Data Tracker Circuit (Sheet 2 of 2), Schematic



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE IN OHMS, ¼W, ±5%
2. ALL TRANSISTORS ARE 2N2907

Figure 9-8. LED Display Board , Schematic

APPENDIX A

ANSI® SPECIFICATION X356-1977

American National Standard Recorded Magnetic Tape Cartridge for Information Interchange 4 Track, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded

Secretariat

Computer and Business Equipment Manufacturers Association

Approved June 25, 1976

American National Standards Institute, Inc

Contents

American National Standard Recorded Magnetic Tape Cartridge for Information Interchange 4 Track, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded

1. Scope and Purpose

1.1 Scope. This American National Standard is intended to provide a format and recording standard for a 0.250-inch (6.30-mm) -wide, 4-track, magnetic tape in a cartridge to be used for information interchange between information processing systems, communication systems, and associated equipment utilizing the American National Standard Code for Information Interchange, X3.4-1977 (ASCII). This standard refers solely to recording on the 0.250-inch (6.30-mm) magnetic tape cartridge and complements American National Standard Unrecorded Magnetic Tape Cartridge for Information Interchange, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded, X3.55-1977, where the following sections are dealt with in detail: general requirements, definition, tape and cartridge, physical and magnetic requirements, speed requirements, and write enable feature. Compliance with the unrecorded standard is a requirement for information interchange.

CAUTION NOTICE. The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions, to applicants desiring to obtain such a license. Details may be obtained from the publisher.

No representation or warranty is made or implied that this is the only license that may be required to avoid infringement in the use of this standard.

1.2 Purpose

1.2.1 This standard defines the requirements and supporting test methods necessary to ensure interchange at acceptable performance levels. It is distinct from a specification in that it delineates a minimum of restrictions consistent with compatibility in interchange transactions.

1.2.2 Wherever feasible, quantitative performance levels that will be met or exceeded as a result of conformance to this standard are given. Quantiative limits for some of the requirements falling within the scope of this standard are not stated but are left to agreement between interchange parties. Standard test methods and measurement procedures shall be used to establish such quantities.

1.2.3 In this standard toleranced dimensions are converted from U.S. customary units to SI units in accordance with Method B in ISO R 370-1975, Toleranced Dimensions – Conversion from Inches to Millimeters and Vice Versa.[1,2] U.S. customary units are the original dimensions in this standard.

1.2.4 Except as indicated in 1.2.2 above, interchange parties conforming to the applicable standards should be able to achieve compatibility without need for additional exchange of technical information.

2. Definitions and Explanations of Terms as Used in This Standard

2.1 Magnetic Tape Cartridge. A magnetic tape cartridge refers to a cartridge containing 0.250-inch (6.30-mm) -wide magnetic tape wound on two coplanar hubs with an internal drive belt to transport the tape between the hubs (see Fig. 1).

2.2 Flux Reversal. The position of a flux reversal is defined as that point which exhibits the maximum free space flux density normal to the tape surface.

2.3 Density. Density refers to the number of data bit flux reversals per unit length of recorded track, exclusive of phase flux reversals; density is usually expressed in bits per inch.

2.4 Recorded Block. A recorded block is a group of contiguously recorded bits which extend from one interblock gap to the next interblock gap. This includes the data bits, CRC, and synchronizing bits, such as preamble and postamble (see Fig. 2).

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[1] In the corresponding national standards of ISO member nations, additional rounding may be done to produce preferred values. These values usually lie within the original tolerance ranges.

[2] Available from American National Standards Institute, Inc, 1430 Broadway, New York, N.Y. 10018.

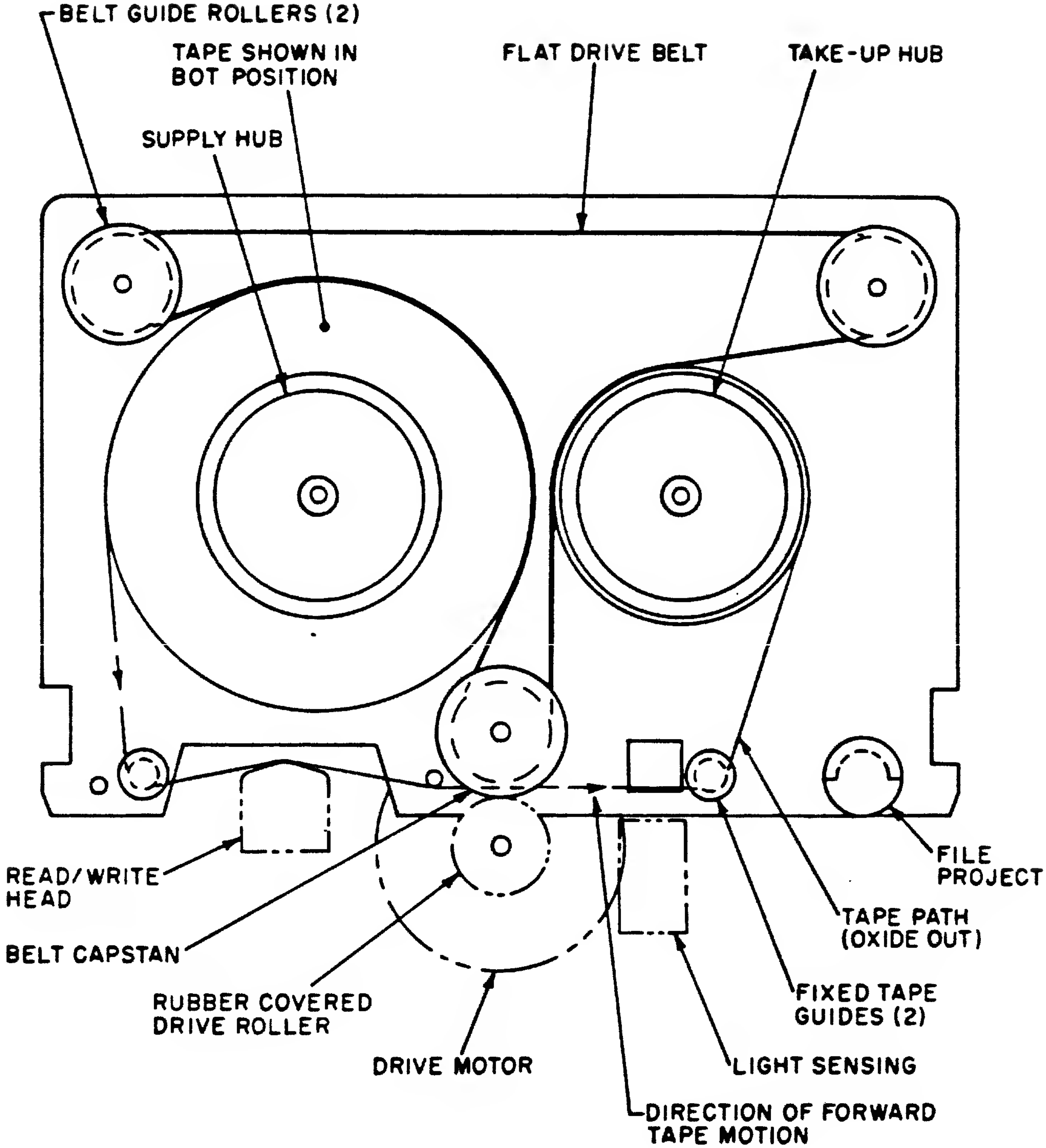


Fig. 1
Cartridge Diagram

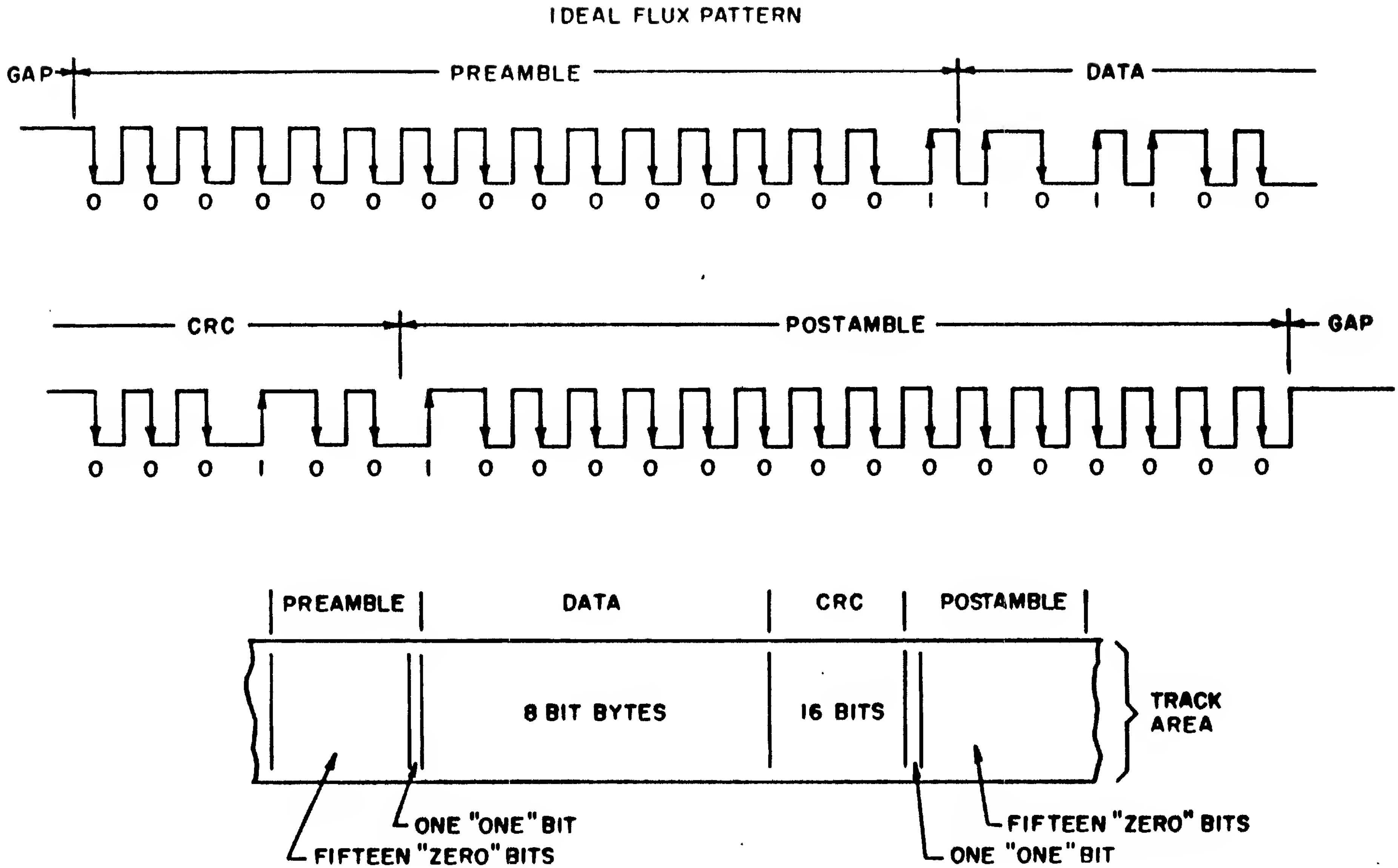


Fig. 2
Recorded Block

2.5 Data Block. A data block is a group of contiguously recorded bits, less CRC and synchronizing bits, such as preambles and postambles, considered and transported as a unit containing one or more logical records, or portions of logical records.

2.6 Interblock Gap. An interblock gap is a dc erased section of tape separating blocks of information.

2.7 In Contact. "In contact" refers to an operating condition in which the oxide side of a tape is in physical contact with a magnetic head.

2.8 Control Block (Tape Mark). A control block (tape mark) is special control block recorded on magnetic tape to serve as a separator between files and file labels, or to define the end of recorded data.

2.9 Reference Alignment Cartridge. The reference alignment cartridge is a cartridge containing tape on which continuous information has been recorded. The reference alignment cartridge has been optimized for perpendicularity of the written flux transition to the cartridge positioning plane.

2.10 Preamble. A preamble is a special sequence of bits recorded at the beginning of each recorded block.

2.11 Postamble. A postamble is a special sequence of bits recorded at the end of each recorded block.

2.12 CRC Character. The CRC is a 16-bit cyclic redundancy check character that is written after the data and preceding the postamble of each block for the purpose of error detection.

2.13 Beginning of Tape (BOT) Marker. The BOT marker is a set of two holes punched in the tape. There are three sets of holes provided, the innermost of which is used for the purpose of identifying the storage position for the cartridge. In the storage position, all of the permissible recording area is wound on the supply hub and is protected by at least one layer of tape. Cartridges to be interchanged shall be rewound to the storage position prior to interchange. The additional sets of holes are used to ensure reliability of detection (see Fig. 3).

2.14 End of Tape (EOT) Marker. The EOT marker is a single hole punched in the tape. There are three such holes along a single line. The first to pass the photo sensor during forward operation indicates that the permissible recording area has been exceeded. The additional sets of holes are used to ensure reliability of detection (see Fig. 4).

2.15 Load Point (LP) Marker. The LP marker is one hole punched in the tape to indicate the beginning of the permissible recording area in the forward direction (see Fig. 3).

2.16 Early Warning (EW) Marker. The EW marker is one hole punched in the tape between recorded tracks for the purpose of indicating the approaching end of the permissible recording area in the forward direction. Recording must halt before the EOT marker is sensed (see Fig. 3).

2.17 Amplitude Reference Tape. An amplitude reference tape is a tape selected for a given property to establish the reference output signal level when recorded with continuous "1's" at 3200 frpi [flux reversals per inch] (126 frpmm) [flux reversals per millimeter].

2.18 Standard Reference Current. The standard reference current is the minimum write current which, when applied to the amplitude reference tape, causes an output signal equal to 95% of the maximum output at 3200 frpi (126 frpmm).

2.19 Standard Reference Amplitude. The standard reference amplitude is the peak-to-peak output level which is read from the amplitude reference tape when written at 3200 frpi (126 frpmm) with a write current that is 1.5 times the value of the standard reference current.

2.20 Track. A track is a longitudinal area on the tape along which a series of magnetic signals may be recorded.

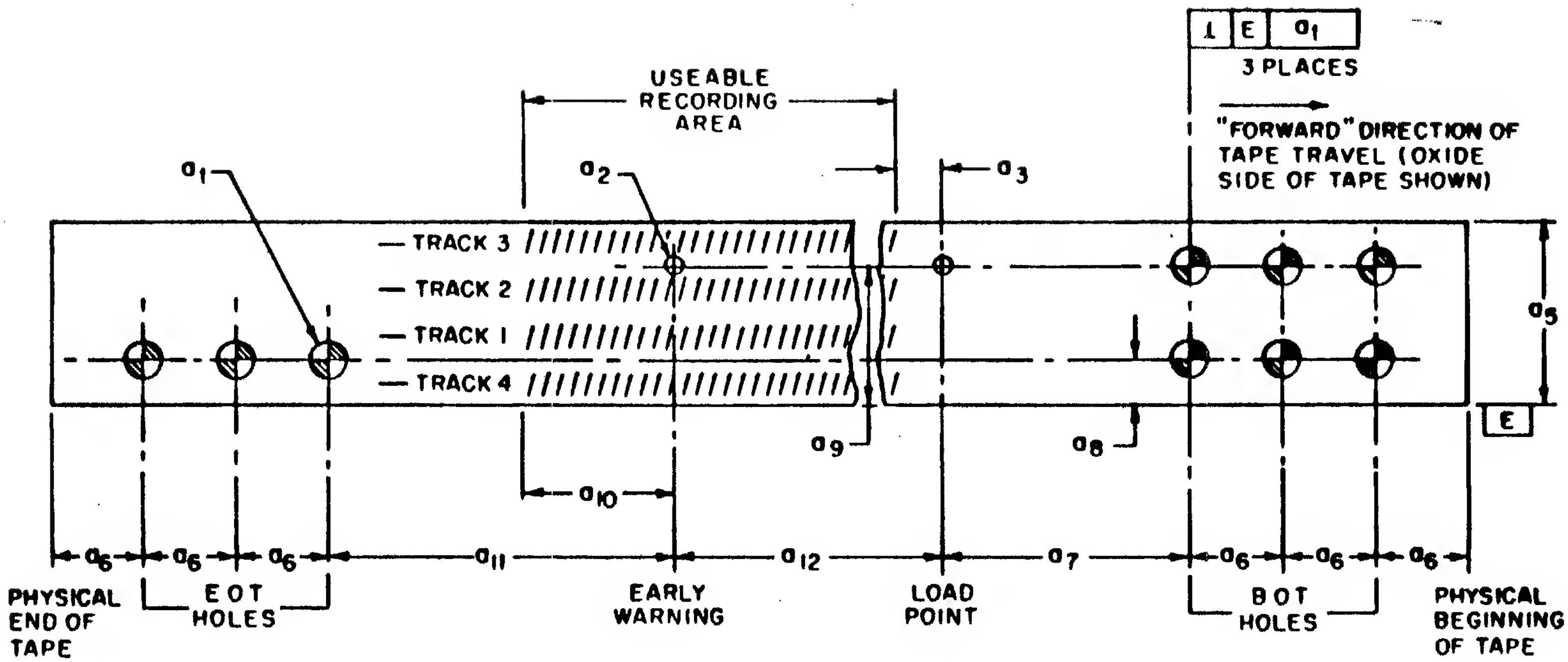
3. Recording

3.1 Method. The method of recording shall be phase encoding. Each data bit requires a reversal of flux polarity in a given direction for a logical "1," and in the opposite direction for a logical "0." Phase flux reversals will occur at the nominal midpoint between data bits in order to permit the proper polarity shift for the following data bit. "Self-clocking" is attained in this recording method through the consistent occurrence of flux reversals for each data bit, 1600 times per inch (63 times per millimeter). The erasing process described in 3.6 forms part of the recording procedure.

3.1.1 Data Bit "1." A "1" data bit is defined as a flux reversal to the same polarity as the interblock gap when reading in the forward direction.

3.1.2 Data Bit "0." A "0" data bit is defined as a flux reversal to the polarity that is opposite to that of the interblock gap when reading in the forward direction.

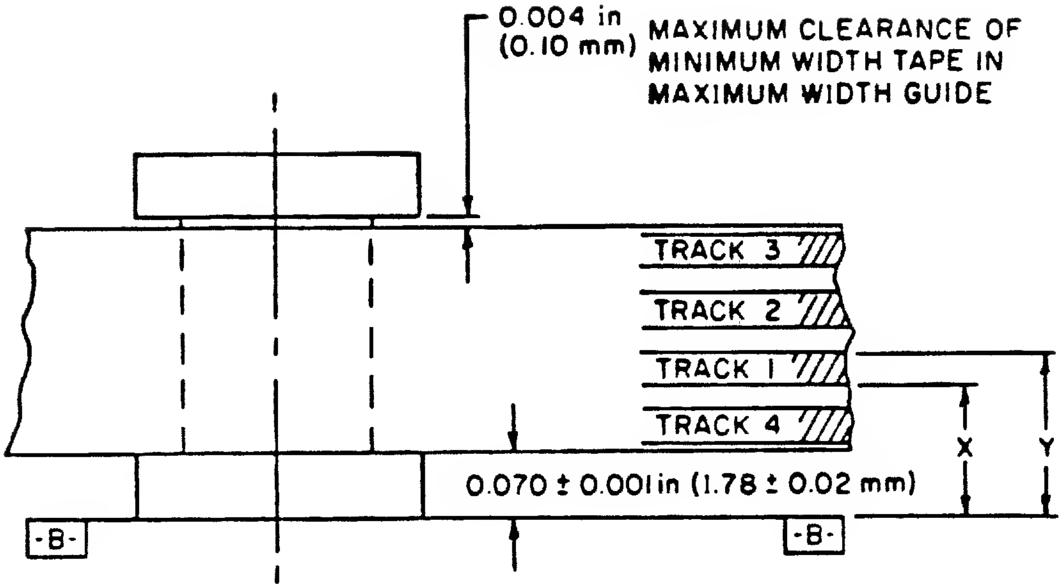
3.1.3 Phase Flux Reversals. Flux reversals that occur at the nominal midpoint between successive "1" bits or between successive "0" bits to establish proper



Dimension	Inches	Millimeters
a_1	0.046 (± 0.002)*	1.17 (± 0.05)*
a_2	0.023 (± 0.002)†	0.58 (± 0.05)†
a_3	6‡	152.4‡
a_4	0.005	0.12
a_5	0.2470 (± 0.0010, – 0.0015)	6.274 (+ 0.025, – 0.038)
a_6 (6X)	18 (± 3)	457 (± 76)
a_7	36 (± 3)	914 (± 76)
a_8	0.059 (± 0.002)	1.50 (± 0.05)
a_9	0.187 (± 0.002)	4.75 (± 0.05)
a_{10}	36§	915§
a_{11}	48 (± 3)	1219 (± 76)
	Feet	Meters
a_{12}	300 (+ 10, – 0)	91.5 (+ 3.0, – 0.0)

*Diameter (9 holes).
†Diameter (2 holes).
‡Minimum.
§Maximum

Fig. 3
Tape Position Holes and Recording Format



	Inches				Millimeters			
	Dimension X		Dimension Y		Dimension X		Dimension Y	
Track	Max	Min	Max	Min	Max	Min	Max	Min
1	0.146	0.130	0.194	0.178	3.71	3.30	4.93	4.52
2	0.210	0.194	0.258	0.242	5.33	4.93	6.55	6.15
3	0.274	0.258	0.322	0.306	6.96	6.55	8.18	7.77
4	0.082	0.066	0.130	0.114	2.08	1.68	3.30	2.90

Fig. 4
Tape Guide and Track Dimensions

polarity for the following data bit are called phase flux reversals.

3.2 **Equipment.** The equipment and cartridge used for interchange must satisfy the requirements of 3.3 through 3.6. All signal measurements are made at a point in the read chain where the amplitude is proportional to the rate of change of the longitudinal component of the flux at the tape surface. For the purpose of relating bit spacing along the tape to cartridge driving speed, the ratio of tape speed to the surface speed of the belt capstan shall be assumed to be exactly 0.76.

3.3 **Density.** The nominal recording density shall be 1600 bits per inch (63 bpmm). Density statements in bits per inch (bpmm) are always exclusive of phase flux reversals.

3.3.1 Bit Spacing. The nominal bit spacing exclusive of phase flux reversals is 625 μin (15.9 μm).

3.3.2 Long-Term Average Bit Spacing. The long-term average bit spacing shall be within ± 3% of the nominal spacing. This average shall be measured over a minimum tape length of 150 inches (3.81 mm).

3.3.3 Short-Term Average Bit Spacing. The short-term average bit spacing referred to a particular bit spacing is the average of the preceding four bit spacings. The short-term average bit spacing, exclusive of the effects of 3.4, shall be within ± 7% of the long-term average bit spacing. In addition, the short-term average bit spacing shall not change at a greater rate than 2% per bit.

3.4 **Flux Reversal Spacing.** To determine the instantaneous spacing between any two flux transitions, 3.4.1 and 3.4.2 must be taken together.

3.4.1 Data Bit to Data Bit Tolerance. The spacing between successive data bits without an intervening phase flux reversal shall be between 88% and 105% of the short-term average bit spacing. The spacing between successive data bits with an intervening phase flux reversal shall be between 95% and 112% of the short-term average bit spacing.

3.4.2 Data Bit to Phase Flux Reversal Tolerance. The spacing between a data bit and any adjacent phase

flux reversal shall be between 44% and 56% of the short-term average bit spacing.

3.5 Signal Amplitude. Paragraphs 3.5.1 through 3.5.5 apply to writing and reading in contact.

3.5.1 Average Signal Amplitude. The average peak-to-peak signal amplitude of the interchange tape at 3200 frpi (126 frpmm) shall deviate no more than +50% or -35% from the standard reference amplitude. Averaging shall be done over a minimum of 3200 flux reversals, which, for interchange cartridges, may be segmented into groups.

3.5.2 Maximum Signal Amplitude. The peak-to-peak signal amplitude at 1600 frpi (63 frpmm) shall be less than three times the standard reference amplitude.

3.5.3 Minimum Signal Amplitude. No tape when interchanged shall contain any adjacent flux reversals whose peak-to-peak signal amplitude is less than 20% of the standard reference amplitude.

3.5.4 Azimuth Alignment. When adjusted for maximum output, the read head azimuth angles for a referance alignment cartridge and for the interchange cartridge shall not differ by more than ± 10 minutes.

3.5.5 Rejected Regions. A rejected region is an area of tape extending across the track width and not more than 1.0 inch (25.4 mm) in length which exhibits permanent dropouts on two consecutive passes. The number of rejected regions in an interchange environment is a matter of agreement between interchange parties.

3.6 Erase

3.6.1 Erase Direction. The tape shall be magnetized so that the beginning of tape is a north-seeking pole.

3.6.2 Erase Function. Erasure, whether by the write head or the erase head, shall ensure that the level of the read back signal amplitude is below 3% of the average signal amplitude at 3200 frpi (126 frpmm).

4. Format

4.1 Number of Tracks. There will be up to four tracks. Each track is a data track and will be independent of the other tracks. Individual read/write units may provide one, two, or four tracks. The number one track must be readable on all units. The number two track is readable on either two or four track units (that is, track positions, track widths, and erased areas must be compatible between units with a varying number of tracks).

4.2 Use of Tracks. Each track shall be written in serial fashion starting near the BOT and continuing toward the EOT, with a rewind to BOT before initiating writing on the next track. All tracks are primarily data tracks; however, if one or more tracks are used for other than data, the number one track must always be a data track. Track locations and designations are shown in Fig. 4.

4.3 Byte and Code Requirements

4.3.1 Byte Size. The system shall be capable of reading and writing an 8-bit byte. The ASCII 7-bit coded character set (ANSI X3.4-1977) is recorded in the seven least significant bit-positions of an 8-bit byte. The eighth position is always a zero bit.

4.3.2 Bit Sequence. Bits are recorded on the tape in serial fashion. The low-order data bit (b_1) is recorded first, then the next data bit (b_2), and so on to the high-order data bit (b_8). The data bits of ASCII are numbered $b_8, b_7, b_6, b_5, b_4, b_3, b_2$, and b_1 from the high order to low order.

4.4 Gaps

4.4.1 Initial Gap. The initial gap is the distance between the load point and the first bit of the first recorded block on tape. The minimum distance is 6.0 inches (152.4 mm).

4.4.2 Interblock Gap (IBG). For data interchange, the length of the interblock gap shall be a minimum of 1.2 inches (30.5 mm), and a maximum of 48 inches (1.22 m). Preambles and postambles are not considered as part of the IBG.

4.4.3 Gap Polarity. The polarity of all gaps shall be established by the erase function in the direction specified in 3.6.1.

4.4.4 Integrity of Gaps. The gaps shall be dc erased. Immediately before and after each block there shall be a length of at least 0.09 in (2.5 mm) in which, exclusive of residual edge signals, there is no flux discontinuity capable of producing a read signal of more than 10% of half the standard reference amplitude.

In the remaining part of the gap one burst of spurious transitions can be tolerated, provided that the total number of transitions are seven or less.

4.5 Block Length

4.5.1 Minimum Data Block Length. The minimum data block is that group of bits, exclusive of preamble and postamble, and CRC, that can be considered a valid block. This minimum block length, exclusive of the tape mark, is six 8-bit data bytes.

4.5.2 Maximum Data Block Length. The maximum data block length is 2048 bytes.

4.5.3 Preamble. Preceding the data in each block a preamble shall be written consisting of 15 zero bits followed by a 1-bit (see Fig. 2). The preamble may be used to establish a timing sequence so that data can be read in the forward direction.

4.5.4 Postamble. Following the data and the CRC character in each block, a postamble shall be written

consisting of one 1-bit followed by 15 zero bits (see Fig. 2). The postamble may be used to establish a timing sequence so that data may be read in the reverse direction.

4.6 Control Block (Tape Mark). The control block (tape mark) shall consist of a preamble, two bytes of eight "zero" bits each, and a postamble.

4.7 CRC Character. A 16-bit CRC shall be written in each data block following the data and immediately preceding the postamble. The CRC is generated by the polynomial $X^{16} + X^{15} + X^2 + 1$.

4.8 Useable Recording Area. All data to be interchanged shall be written within the useable recording area as defined in Fig. 3.

WARRANTY

A. The Seller warrants Products against defects in material and workmanship for six (6) months from the date of original shipment for end users and for 90 days for OEMs. The Seller's liability is limited to the repair or replacement of Products which prove to be defective during the Warranty period. There is no charge under the Warranty except for transportation charges. The Purchaser shall be responsible for Products shipped until received by the Seller.

B. The Seller specifically excludes from the Warranty 1) calibration, 2) fuses, and 3) normal mechanical wear, e.g.; end-of-life on assemblies such as switches, relays, gear trains, etc. is dependent upon number of operations or hours of use, and end-of-life may occur within the Warranty period.

C. The Seller is not liable for consequential damages or for any injury or damage to persons or property resulting from the operation or application of Products.

D. The Warranty is voided if there is evidence that Products have been operated beyond their design range, improperly installed, improperly maintained or physically mistreated.

E. The Seller reserves the right to make changes and improvements to Products without any liability for incorporating such changes or improvements in any Products previously sold, or for any notification to the Purchaser prior to shipment. In the event the Purchaser should require subsequently manufactured lots to be identical to those covered by this Quotation, the Seller will, upon written request, provide a quotation upon a change control program.

F. No other Warranty expressed or implied is offered by the Seller other than the foregoing.

CLAIMS FOR DAMAGE IN SHIPMENT

The purchaser should inspect and functionally test the Product (s) in accordance with the instruction manual as soon as it is received. If the product is damaged in any way, including concealed damage, a claim should be filed immediately with the carrier, or if insured separately, with the purchaser's insurance company.

SHIPPING

On products to be returned under warranty, await receipt of shipping instructions, then forward the instrument prepaid to the destination indicated. The original shipping containers with their appropriate blocking and isolating material is the preferred method of packaging. Any other suitably strong container may be used providing the product is wrapped in a sealed plastic bag and surrounded with at least four inches of shock absorbing material to cushion firmly, preventing movement inside the container.

FACTORY REPAIR DATA

Prior to shipping a unit for repair, contact Qantex Sales or Qantex Customer Service for an Authorization Number. You will be asked for the product model number, description, and reason for return. Enter the information on a form, as shown below, and send it with the unit.

AUTHORIZATION NO. ____

CUSTOMER ______________________________ TEL. ______________

ADDRESS ____

____

EQUIPMENT ____

MODEL NO. __________________ SERIAL NO. ____________________

PROBLEM ____

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